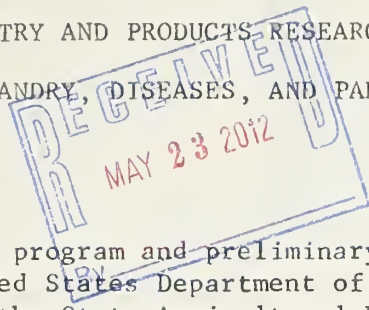


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ANIMAL-POULTRY AND PRODUCTS RESEARCH
OTHER THAN HUSBANDRY, DISEASES, AND PARASITES



A summary of current program and preliminary report of progress of the United States Department of Agriculture and related work of the State Agricultural Experiment Stations.

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

December 31, 1967

United States
Department of
Agriculture



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RESEARCH ADVISORY COMMITTEES

The following Research Advisory Committees were established pursuant to Title III of the Research and Marketing Act of 1946:

- | | |
|-----------------------------------|--------------------------------|
| 1. Farm Resources & Facilities | 8. Cotton |
| 2. Utilization | 9. Grain and Forage Crops |
| 3. Human Nutrition & Consumer Use | 10. Horticultural Crops |
| 4. Marketing | 11. Oilseed and Peanut Crops |
| 5. Agricultural Economics | 12. Plant Science & Entomology |
| 6. Forestry | 13. Sugar |
| 7. Animal & Animal Products | 14. Tobacco |

The source materials used by the advisory committees include organizational unit progress reports and subject matter progress reports. The latter contain information which was first reported in the organizational reports and has been assembled for use by commodity committees. The number prefixes shown below refer to advisory committees listed above.

ORGANIZATIONAL UNIT PROGRESS REPORTS

Agricultural Research Service (ARS)

- 1 - Agricultural Engineering
- 1 - Soil & Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Consumer & Food Economics
- 4 - Market Quality
- 4 - Transportation & Facilities
- 7 - Animal Husbandry
- 7 - Animal Disease & Parasite
- 12 - Crops
- 12 - Entomology

Economic Research Service (ERS)

- 5 - Economic Development
- 4, 5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Economic & Statistical Analysis
- 5 - Foreign Development & Trade
- 5 - Foreign Regional Analysis
- 1, 5 - Natural Resource Economics
- 6 - Forest Service - Research (FS)
- 4, 5 - Farmer Cooperative Service (FCS)
- 4, 5 - Statistical Reporting Service (SRS)

SUBJECT MATTER PROGRESS REPORTS

- 6 - Forestry (other than Forest Service)
- 7 - Animal-Poultry and Products Research Other Than Husbandry, Disease and Parasite
- 8 - Cotton and Cottonseed
- 9 - Grain and Forage Crops
- 10 - Horticultural Crops
- 11 - Oilseed and Peanut
- 13 - Sugar
- 14 - Tobacco

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Animal and Animal Products Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250.

This is one of eight subject matter progress reports listed on the previous page. It contains the results of animal-poultry and products research not included in the progress reports pertaining to "animal husbandry" and "animal diseases and parasites." The information contained in this volume was assembled from the organizational unit progress reports. The subject matter areas are listed below.

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INTRODUCTION

All farm research pertaining to livestock and poultry except engineering and entomology is reported in the "animal husbandry" and "animal disease and parasite" progress reports.

Nutrition, consumer use, and utilization research pertaining to animal-poultry and products is conducted in the Agricultural Research Service Divisions of Human Nutrition, Consumer and Food Economics, Eastern Utilization, and Western Utilization Research and Development. The work comprises investigations of composition and nutritive value; physiological availability of nutrients and their effects; new and improved methods of preparation, preservation, and care in homes, eating establishments and institutions; and with the processing phase and manufacture into products. Also, it is concerned with improved equipment and processes.

Marketing and economic research pertaining to animal-poultry and products is carried on within four services: Agricultural Research Service, Economic Research Service, Farmer Cooperative Service, and Statistical Reporting Service. The work comprises (1) physical and biological aspects of assembly, packaging, transporting, storing and distribution; (2) economic aspects of marketing costs, margins and efficiency, market potential, supply and demand, and situation and outlook; (3) cooperative marketing; and (4) consumer acceptance studies. The divisions in which the work is conducted are: Market Quality, ARS; Transportation and Facilities, ARS; Marketing Economics, ERS; Economic and Statistical Analysis, ERS; Standards and Research, SRS; and under the Cooperative Marketing and Farm Supplies Program, FCS.

Interrelationships among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the Station. Cooperative work is jointly planned, frequently with the participation of representatives of the producers or industry affected. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators which frequently includes resources contributed by the interested producers or industry.

About one-third of industry's contribution to the research effort pertains to farm research. Industry does most of its own poultry breeding research but very little beef breeding research, except the work of large firms like the King Ranch which developed the Santa Gertrudis breed. The scope of operation required for a successful research program in breeding beef cattle because of the size of animal and length of life cycle which tie up a substantial amount of funds is undoubtedly a factor contributing to the amount of public research. In the case of swine there is a real

opportunity for increased participation by industry. The task of evaluating breeds, the performance of breeds in crossing, and the comparison of crossing systems will take more animals than are available at publicly-supported experiment stations.

About equal to the farm research effort in the livestock industry, another one-third is in the utilization field. In contrast with the public research in basic work the industry program places strong emphasis on developmental activities and solving of immediate problems. The work of meatpackers is devoted to finding industrial utilization of byproducts, quality control devices, improved formulation of products, improved handling and plant arrangement. Independent laboratories and foundations take on short time problem-solving for clients in the meat industry. Pharmaceutical firms carry on research on extraction of biologically active substances from meat byproducts such as hormones from glands and with the development of agents such as antibiotics for use in meat processing.

The contributions of producers and industry to the work of the State Stations and the Department have been an important factor in the success of their research programs. Producers offer herds and facilities for testing products and practices used in production. Likewise, processors and retailers offer facilities and products for use by public research agencies. Many problems in the economics of marketing cannot be transferred to a laboratory, experimental plot, or other simulated situation. The results of economic research conducted cooperatively is of great value to industry, especially in cases where public research can provide comparison and analysis. Even large firms that have a research staff do not have access to the plants and records of competitors.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Heredity Affects Level of Blood Cholesterol. ARS scientists find that blood cholesterol levels in experimental animals may be high even when the diet throughout life is low in fat and cholesterol. When a diet low in fat and cholesterol was fed to one strain of rats, blood cholesterol was within a range considered normal. When the same diet was fed to a second strain of rats, blood cholesterol values were about twice as high and reached levels sufficiently elevated to be a cause for concern. Regardless of the level of blood cholesterol, liver cholesterol values were normal in both strains.

Some Dietary Fats may Trigger the Development of Goiter in Iodine Deficient Rats. ARS contract research with a Columbia University scientist suggests that certain fats and oils contain substances that aggravate the development of enlarged thyroids characteristic of goiter - a finding that may be of importance in iodine deficient areas. From weaning until death, rats were fed diets that contained marginal amounts of iodine. The diets

varied only in the type of fat used. Fat constituted 20% by weight of each diet. In contrast to normal thyroids of 23-31 mg., olive oil produced a high incidence of thyroids weighing more than 100 mg. The incidence of large thyroids was low when the diets contained butter, pork, or beef. Chicken fat, soybean oil, and corn oil were intermediate in their effect on thyroid size. Mild oxidation of the fats did not alter response.

Eating Quality of Frozen Turkeys can be Comparable to that of Fresh Turkeys.

Cooking procedures have been developed by ARS scientists to assure optimum eating quality of frozen whole turkeys. This research will help consumers get more satisfaction from use of frozen turkeys. Eating quality was shown to be similar for fresh and frozen-thawed turkeys when cooked for equal periods of time rather than to the same end temperature. The most frequent consumer complaints about turkey are the dry texture and decreased tenderness sometimes found in light meat. These undesirable characteristics are markedly reduced by procedures which eliminate overcooking. Cooking recommendations which have been issued recently stress the same cooking time for fresh and frozen-thawed turkeys. Thus, if a meat thermometer is used the final temperature for frozen-thawed turkeys should be about 10% lower than that recommended for fresh turkeys.

Heat-treated Milk Fat for Food Use. The flavor of many foods may be enhanced through the use of heat-treated milk fat. It imparts a desirable flavor ranging from buttery and butterscotch to caramel--depending on the treatment--to the food to which it is added. This distinctive improved flavor is pleasing to consumers.

In the process, sweet cream is pasteurized, cooled and churned into butter, which is subsequently heated to 220°F. to evaporate water. The remaining mixture of milk fat, protein, lactose and milk salts is heated to 230°F. to 280°F., depending on the flavor intensity desired. Then the nonfat milk solids are removed.

The product, which is 99.8 percent milk fat, maintains its flavor during storage, even at room temperature. It has been successfully tested in candy, ice cream and ice milk, and in cooking meats, fish and other foods. As a flavor source, less of the heat-treated milk fat is needed than butter, which has long been used to flavor foods.

Commercial Use of Foam-Spray Drying for Skim Milk. Foam-spray drying, a technique in which air or some other gas at high pressure is injected into the liquid-feed line of a spray dryer, has now been applied to the commercial-scale manufacture of nonfat dry milk. In the dryer the gas liquid-feed mixture makes tiny droplets of foam, which dry as expanded particles. These make an "instant" powder--one which quickly dissolves when water is added to it. The new technique provides substantial savings in both capital and operating costs compared to the conventional equipment used to make instant powder. The foam-spray dried skim milk is used in food manufacture and for direct consumer use. Commercial interest is growing and additional applications of the process are anticipated.

Oxidized Flavor in Milk Averted by Improved Feed Practices. ARS-supported research at the University of Maryland has demonstrated that oxidized flavor in milk--a defect associated with winter and dry-lot feeding of dairy cows--may be averted by supplementing the dairy ration with vitamin E. The vitamin may be added as a concentrate by the feed manufacturer. The vitamin E naturally present in most green forages may be preserved by ensiling or by rapid dehydration of freshly harvested forage. The information developed by the research scientists will permit dairy farmers to provide for adequate vitamin E by proper selection and harvesting of forage for silage. The research findings will be applicable to dry-lot dairy operations and to the manufacture of dehydrated alfalfa and other forages.

Industrial Chemicals from Surplus Fats. Department scientists have perfected several chemical reactions which yield a variety of industrially valuable aromatic compounds from the oleic acid in surplus tallow. For example, phenylstearic acid is a viscous oil which remains liquid over a wide temperature range (-50 to +300°C.). It is a good lubricant and surface active agent. The properties of another compound, hydroxyphenylstearic acid, make it useful in lubricants, antioxidants, plasticizers and resin intermediates. Two large chemical corporations have developed industrial processes for making these materials. Phenylstearic acid is expected to sell at 28-33 cents a pound, and hydroxyphenylstearic acid at 35-40 cents a pound. Within a few years, millions of pounds of phenylstearic acid will find use in the lubricant field alone. If easily available at low cost, these compounds should provide an important new outlet for surplus inedible fats.

Improved Glove Leather. As a result of USDA leather tanning research, golfers will soon be able to buy leather gloves that will last all season or longer under hard usage. The gloves will remain soft and comfortable throughout their useful life even though they are wet many times with perspiration and washed repeatedly with soap and water. Without doubt, similar gloves for other sports, such as handball, will follow.

The ARS-developed tannage is applicable to both dress and work gloves and has attracted the attention of many tanners and glove manufacturers. The industry appreciates the value of this research, for substantial amounts of leather go into glovemaking. In 1965, for example, the USA produced and imported well over 25 million dozen pairs of leather and part-leather gloves.

Leather Defect Traced to Inherent Weakness in Hides. Cooperative research between ARS and the University of Cincinnati has established that "pulpy butt" leather results from hide defects and not from poor preservation or improper processing practices. The afflicted hides were shown to possess an abnormal fiber orientation, especially in the back region, which weakens the leather for shoemaking. The fibers are arranged in a loose and vertical pattern rather than a compact and horizontal weave, as seen in normal hides. These characteristic fiber structures were observed in at least 10% of the plumper Hereford steer hides and to a lesser extent in the heavier Angus hides examined. As a consequence of this research, the tanning industry

may be able to prevent an annual \$5 to \$10 million loss. It is presently working on means for detecting the defective leathers and removing them from shoemaking channels.

Comfort Properties of Shoe Leather Determined. Indian scientists working under a PL-480 research grant have reported on the properties of leather which contribute to foot health, comfort and wearability. With continued use, the unique three-dimensional protein fiber network of leather was shown to increase in flexibility; it conformed to the foot with increasing humidity; it became more permeable to both air and water vapor. Leather was found to absorb an appreciable quantity of perspiration, thereby lowering the humidity within the shoe and making it more comfortable. As yet, these properties have not been duplicated in any of the man-made substitutes. Continued research to detect and measure the unique characteristics of leather will be helpful in defining and objectively measuring its comfort properties. Properly advertised and promoted, this information should give shoe leather a competitive advantage over the newly-developed synthetic substitutes.

Identification of Meat Smoking Constituents. Out of over 200 compounds which have been reported to be present in wood smoke, ARS scientists discovered that only a few phenolic constituents are needed to impart a highly acceptable smoked flavor to meat products. In this work, the wood smoke was analyzed and separated into many fractions so that the flavoring potential of each could be judged. As this research continues, additional data will be obtained and applied to increasing the effectiveness, the reproducibility and the safety of meat smoking processes.

Color Development in Sausage Making. In recent basic studies on the chemical reactions involved in meat curing, Department scientists have obtained practical information regarding the successful development of stable cured color in sausages. Modern methods of sausage production allow only a minimum time for color formation. Processors, therefore, must add reducing chemicals to accelerate the reaction between nitrite and the natural meat pigment. In these investigations, the rates of reaction for cured meat color formation were determined with various reducing chemicals under sausage-making conditions. The resulting data should prove valuable to meat processors using computer-programmed sausage formulations. It will allow them to choose the best reductant and the best set of conditions for any of several practical situations.

Improvements in WURLAN Processing of Wool. Department scientists have improved the conditions of WURLAN treatment and have found that a newly available cheap solvent may be used to achieve a more than 20% reduction in chemical costs, more effective shrinkproofing, softer handle for the treated fabrics, improved stability of the reactant baths, and simplification of process control. The highly promising laboratory results obtained with worsted-type fabrics are attracting increased industrial interest, and steps are being taken to adapt these improvements to commercial processing of wool.

Basic Advances Made in Knittability of Worsted Yarn. Department scientists have provided an entirely new approach to the design of more efficient knitting machinery that will result in better knit garments as well as lower processing costs. The breakthrough resulted from a comprehensive study of the dynamics of knitting worsted-type wool yarns which revealed the complex nature of forces involved in transforming yarns into the characteristic knitted loop configuration. The interrelationships of yarn frictional properties, yarn-metal friction, yarn irregularities, and the shape of knitting cam assemblies led to equipment design and methods of operation that can maximize knitting efficiency of worsted wool yarn.

Freeze-Drying of Poultry Meat. The fundamental rate-limiting processes in freeze drying of poultry meat have been satisfactorily explained by a mathematical model based on the notion that a continuous ice front retreats uniformly to the center of the piece. Heat is transferred by conduction from the surface to the ice front. Water vapor liberated at the ice front moves to the surface of the piece, partly by diffusion and partly by mass flow. Under good vacuum conditions, heat transfer is the rate-limiting factor, and at higher pressures, it is mass transfer.

The model also permits calculation of the effects of adding different gasses to the system. Under helium at a pressure of 5 mm of mercury, heat transfer to the ice surface is greatly improved without a decrease in mass transfer of water vapor away from the ice.

These studies were conducted under contract at the University of California at Berkeley. The results are being applied in work under way to reduce the time and cost of freeze drying poultry meat.

Computer System for Processing Sales and Accounting Data on Livestock Auction Markets. A computer system for processing sales and accounting data on livestock auction markets has been developed under a research cooperative agreement with the Computer Research Center, University of Missouri. The computer has been programmed and laboratory tested and the complete experimental system installed on the Central Missouri Auction Market, Mexico, Mo.

The computer system minimizes the possibility of errors in computations and preparation of records and accounts, speeds up payment for animals following their sale, provides accurate permanent records of all business transacted and could easily be programmed to handle routine accounting tasks such as payrolls. By leasing computer time to or from other firms in their respective localities, the system could be used economically on most of the 1,725 auction markets in the U. S. It is estimated that the system could reduce the clerical labor needed by 50 percent, resulting in a net savings to the livestock marketing industry of an estimated \$3 million annually.

Polystyrene Foam Boxes Reduce the Cost of Marketing Fresh Dressed Poultry.

Use of polystyrene foam boxes instead of wood wirebound boxes can reduce the cost of marketing fresh dressed ice-packed poultry. Based on a truck operating cost of 36 cents per mile and a U. S. average shipping distance of 500 miles per truck shipment, it costs 65.9 cents per 100 pounds to ship ice-packed poultry in wirebound boxes and 56.5 cents per 100 pounds to ship ice-packed poultry in polystyrene foam boxes. Since about 5,179 million pounds of U. S. poultry per year are shipped in wirebound boxes the potential savings if polystyrene boxes were to be used amount to \$4.9 million per year. In addition, laboratory tests indicate that poultry carcass weight loss and microbial breast skin counts are significantly less for poultry packed in polystyrene boxes than in wirebound crates.

Quick Salmonella Test

More rapid procedures were developed for detecting the presence of salmonellae, a group of food poisoning microorganisms, in poultry and egg products. Routine laboratory procedures for detection of these organisms in food products requires a minimum of 4 days, so that in some instances, market distribution of lots of some products may be delayed for this period of time. Under recent USDA and FDA regulations, all egg products must be either pasteurized or otherwise treated to destroy salmonellae. Testing of the product however is still necessary inasmuch as recontamination can occur after treatment. A simple laboratory technique that screens salmonellae-negative samples of dried egg has been developed and is being tested at Beltsville and in a commercial egg-drying plant. The method is based on two biochemical reactions characteristic of most salmonellae, i.e., hydrogen sulfide production and fermentation of mannitol. Failure of either of these reactions to occur when a sample of dried egg is incubated for 42 hours with appropriate media indicates the absence of salmonellae. Only samples showing either reaction need to be tested further. Inasmuch as the majority lots of pasteurized eggs are salmonellae-negative, a great savings in time, equipment and material will be realized by using this technique. Efforts are continuing to refine and shorten this test and to develop more rapid tests for detection of salmonellae-positive samples.

A study on the Competitive Position of the Midwestern Egg Industry, made jointly with the Marketing Economics Division, was completed. This study analyzed trends in egg production and marketing in the Midwest as compared to other regions, and suggested a number of changes to make the Midwest more competitive in the egg industry.

Among the States, Texas reports that an econometric model of the cattle industry was constructed to evaluate which factors influence the producer's decision to produce, feed, or market cattle. This analysis provided separate cattle slaughter forecasting equations, and cattle price forecasting equations for each month of the year.

In Wyoming progress was made in developing and testing alternative models of the cattle-cycle generating mechanism. Prices, inventories, and production of beef were generated by a recursive system of equations; and results were tested against actual data. The goal was to predict annual levels of supplies and prices. A number of demand equations were formulated for feeder cattle on a regional and national basis. In addition, equations were developed to estimate relationships among prices, weights, and breeds of feeder cattle sold at the Torrington livestock auction.

Louisiana reports that: (1) Farm price indexes for Louisiana were computed and published for each month, (2) several publications presenting parish data from the 1964 Census of Agriculture have been started, and (3) progress has been made in estimating farm income by parishes by years.

In Michigan progress has been made in understanding price determining mechanisms operating in agricultural markets for farm inputs and farm products. Price forecasting models are being developed to forecast and predict prices in both the long and short run. The feasibility of a futures market for red tart cherries was evaluated. Trends in the U.S. economy were projected and interpreted for their implications to agricultural markets and farm income.

Dairy.--A study of cooperative marketing activities shows that during the 1957-64 period the number of cooperatives decreased by one-fifth, yet their total volume of milk marketed increased by one-third. The average cooperative increased its volume by three-fifths.

The study also shows more than two-thirds of all dairy cooperatives located in the North Central Region. Many of these organizations operate small creameries and cheese plants and do not have adequate volume to justify installing modern, automated equipment required for low unit cost operations.

Livestock Slaughtering.--A recently completed study indicates that Vermont farmers need a new meat plant to provide a dependable market for their cull dairy cows and veal calves.

Available livestock supplies, market outlets for meat products, and sources of financing make a meat plant feasible if producers will support it with both their livestock and their capital. A plant killing 500 cattle and 1,000 calves a week could add \$280,000 a year to producers' incomes. The Vermont Agri-Business Council is now working to implement the study's recommendations.

Examples of Recent Accomplishments of the State Agricultural Experiment Stations

Construction Standards, Water Supply, Wastes Disposal, and Farmstead Planning.

The increased numbers of cattle in commercial feedlots has resulted in much greater concentration of animal wastes. Such wastes may be washed into streams with runoff from rainfall causing pollution of streams. Research at Kansas State University has begun to measure both quality and quantity of the runoff from streams. Cattle feedlot runoff was shown to be a high strength organic waste containing large concentrations of nitrogen. Based on organic matter content, one gallon of feedlot runoff is equivalent to two to seven gallons of average municipal sewage. Research is continuing to develop methodology that will minimize pollution from feedlots.

Microbial Content of Four Frozen Meat Products. The bacterial content of commercially frozen beef chop suey, beef stew, breaded pork patties and chicken livers was investigated. After purchase from retail stores, the products were stored at -1°C . for no longer than two weeks. They were sampled both in the frozen "as purchased" form and in the cooked form. Of the "as purchased" samples beef stew had the lowest total count (195,000 bacteria per gram) and pork patties the highest (399,300 per gram). Coliform bacteria were found in the chicken livers and pork patties but not in the other products. Enterococci and Staphylococci were found in all four products. Small numbers of noncoagulase-positive Staphylococci survived cooking in over one-half of the samples. Neither the coliform bacteria nor the Enterococci survived cooking. These findings demonstrate the importance of thorough cooking and strict adherence to storage directions.

Meat Packaged in Edible Film. University of Illinois food scientists have developed an edible film for packaging meat that minimizes bacterial growth, moisture loss, and pigment loss. The film is prepared from sodium alginate, crystalline corn syrup solids, and calcium propionate. In comparative studies at 3°C . with rib-eye steaks, control samples were spoiled after 6 days whereas the samples dipped in the film preparation did not spoil until after 10-12 days. Dipped samples retained red pigment for 10-12 days, but the control samples were a dark brown color after 7 days. Samples were judged to have acceptable odor, flavor, and texture after storing 10 days at 3°C .

Rapid Ham Processing. Recent research at Oklahoma State University, cooperative with USDA, shows that ham can be satisfactorily processed within 15 hours from time of slaughter. The shorter processing time is accomplished by eliminating the 24-hour chill treatment. Hams were alternately assigned to rapid or conventional processing. Bacterial counts and pH changes were determined as they were influenced by processing techniques. As a result of the rapid processing, curing, pH, smoking, and cooking there was a reduction in associative vegetative bacteria. This research indicates that major bacteriological problems do not exist in the accelerated processing of hams.

Sterile Tissue For Meats Research. Sterile tissue techniques are being used by researchers at the Ohio Agricultural Research and Development Center to remove germ-free samples of tissue from a carcass. This technique provides samples that may be stored at room temperature for extended periods. These unprocessed samples provide excellent control material for microbiological studies to determine the microflora that affect the flavor and quality of meat. Basic information from this research could provide leads to improving color retention, flavor, and shelf life of meats.

Antibiotic Activity of Lactobacilli. As a result of the claimed therapeutic value of acidophilus milk, researchers at the Nebraska Agricultural Experiment Station investigated the antibacterial activity of strains of Lactobacillus acidophilus. One strain was shown to be inhibitory toward gram-positive and gram-negative organisms. Milk was found to be the best media for producing maximum antibacterial activity. Maximum activity occurred at 37°C. with an incubation period of 48 hours. The antibiotic, tentatively named "Acidophilin," has been partially purified and found to be active against several bacterial pathogens and nontoxic to rats.

Performance of Egg Yolk Solids. Addition of carbohydrates to liquid egg yolk prior to spray drying affects foaming power and fat availability. Iowa food scientists investigated the mechanism underlying these interactions by the use of commercial-type mixtures of carbohydrates and egg yolk, and by model systems composed of various carbohydrates and purified egg yolk components. Low-density lipoproteins, isolated by preparative ultracentrifugation, exhibited functional properties similar to native egg yolk. These lipoproteins are believed to play an important role in egg yolk functional performance. It is proposed that carbohydrate molecules replace the water of hydration, thereby stabilizing the lipoprotein micellar structure during drying and thus prevent release of foam damaging lipid.

Emulsifying ability of poultry meat. Interest in further processing of poultry products has lead New York (Cornell) scientists to investigate the emulsifying properties of meat obtained from the various parts of fowl, fryer-roosters and turkeys. Parts were analyzed for collagen content and used to prepare basic meat emulsions. The emulsion was evaluated by determining the volume of oil required to break it. The collagen content of poultry meat was found to give an excellent estimate of its emulsifying capacity. Breast and thigh muscles were shown to have a higher emulsifying capacity than gizzard, heart and skin. Light fowl had the poorest emulsifying properties of all meat.

Shelf-life of broilers related to composition. Georgia food researchers have shown that the level of unsaturated fatty acids and, consequently, the development of rancidity in broiler tissues can be controlled by (a) dietary factors such as protein level, type of added fat and anti-

oxidant level; (b) method of packaging; and type of product fabricated from the poultry meat. The fat accounts for from 10 to 20 per cent of the total weight of uncooked broiler meat. A part of this fat is composed of certain phospholipids which have been found to contain high quantities of unsaturated fatty acids.

Replica-plating technique for food bacteria. A replica-plating technique was developed to obtain a rapid quantitative examination of the viable microbial flora on foods during storage. Experiments on milk and milk products disclosed the level and type of initial population and the rate and development of the various bacterial types during storage. Treatment of the food with heat or chemicals introduced a selective factor. The extent to which one or more groups of microorganisms participated in the terminal spoilage pattern depended on the initial level of viable population, the relative resistance to the treatment and the ability to grow under the condition of storage. Texas researchers report that this information, coupled with knowledge of the biochemical characteristics of these species, may be used to predict shelf life, possible spoilage pattern and potential hazards to public health.

Wholesomeness of Poultry Carcasses. Wholesomeness of foods means different things to different people. Research on the evaluation of wholesomeness of turkey and chicken carcasses was approved by inoculation of live birds with several common diseases associated with condemnation. The birds were then slaughtered in commercial processing plants. They were inspected by an experienced USDA inspection veterinarian, a trained panel of food technologists and technicians, and an untrained consumer panel of housewives. Results showed (1) a trained veterinarian condemned relatively few birds known to be in an active stage of disease, (2) panels of laymen used few criteria in common with the veterinarian in deciding whether or not poultry carcasses were wholesome, and (3) the trained panel was hypercritical of all carcasses compared with the untrained consumer panel. More research is needed to elaborate the important factors in influencing wholesomeness.

Simple Method for Analysis of the Fatty Acid Composition of Milk Fats. Since certain milk fats contain short-chain acids, a method was needed that would prevent their loss by volatilization or through incomplete extraction from reaction mixtures. In addition, the method should separate ester derivatives on gas chromatography. Such a method was developed. The new procedure consists of making ethyl esters by transesterification with sodium ethoxide and diethyl carbonate. Extraction of the esters is not necessary and the reaction takes place readily at room temperature.

I. FARM RESEARCH

LIVESTOCK INSECTS AND OTHER ARTHROPODS

Entomology Research Division, ARS

Problem. Insects and other related arthropods attack all classes of livestock and poultry causing estimated annual losses of \$877,850,000. Losses are attributed to direct attack of arthropods, causing losses in weight gains and milk and egg production, and losses in the value of livestock products such as meat, hides, and wool. Additional losses result from livestock and poultry diseases spread by arthropod vectors. A large variety of insects and other arthropods affect livestock including mosquitoes and biting gnats, house flies, horse flies and deer flies, ticks and keds, the face fly, the stable fly, the horn fly, cattle grubs and other bots, lice, mites, and fleeceworms. Practical but not adequate control methods for many of these livestock pests have been developed, but no satisfactory methods of protecting livestock and poultry from mosquitoes, biting gnats, horse flies, deer flies, and stable flies have been found. Development by insects of resistance to control chemicals is a continuing threat to current effective chemical methods of control. The occurrence of insecticide residues in meat and animal products restricts the usefulness of some chemical control methods. Continued basic and applied research is needed to develop new, safer, more effective chemical control agents and methods of using them as well as other methods, such as management practices, sterilization, attractants, and biological control into highly effective integrated means of control or eradication. Research is also needed to study the role of insects in the spread of diseases of livestock and poultry.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing, long-term program involving basic and applied research on the biology and control of insects and related arthropods which affect the health and productivity of all classes of livestock. The total Federal scientific effort devoted to research on livestock insects is 28.5 scientific man-years and includes studies on: (1) beef, horse and swine insects; (2) dairy cattle insects; (3) sheep and goat insects, and (4) poultry insects. Research is conducted on: (A) basic biology, physiology, and nutrition; (B) conventional insecticide control methods; (C) insect parasites, predators, and pathogens; (D) insect sterility and other new approaches to control; (E) insecticide residue determinations; (F) attractants; and (G) insect vectors of animal diseases. The following tabulation indicates the distribution of scientific man-years between commodity groups (1-4) and types of research (A-G).

	A	B	C	D	E	F	G	TOTALS
1	2.5	3.3	1.1	2.0	0.7	0.4	0.6	10.6
2	1.5	3.3	1.2	2.5	0.7	0.4	0.6	10.2
3	1.0	1.0	0.1	---	---	0.3	1.0	3.4
4	0.5	1.2	1.1	1.0	0.1	0.4	---	4.3
Totals	5.5	8.8	3.5	5.5	1.5	1.5	2.2	28.5*

* Plus 1.5 man-years program leadership

Federal support in research grants, contracts, and cooperative agreements provides for 4.6 scientific man-years. Commodity distribution is 1.9 to beef insects; 1.4 to dairy insects; 0.9 to poultry insects, and 0.4 to sheep and goat insects. Research area distribution is 2.1 to basic biology, physiology, and nutrition; 0.8 to conventional insecticide control methods; 0.8 to insect parasites, predators, and pathogens; 0.5 to insect sterility and other new approaches to control; and 0.5 to attractants and repellents. These extramural research projects are located at the following institutions: University of California at Berkeley, University of California at Davis, University of Georgia, University of Kentucky, University of Southwestern Louisiana, McNeese State College, Louisiana State University and A & M College, Mississippi Agricultural Experiment Station, Mississippi State University, State College, New Mexico State University, Oklahoma State University Experiment Station, University of Utah, Virginia Polytechnic Institute, University of Wyoming, Instituto Nacional de Investigaciones Agrícolas (Mexico), and University of Nebraska Agricultural Experiment Station.

Additional research is conducted under P.L. 480 grants. A13-ENT-3, "Investigations on the biology of dung beetles in Korea and their role in the prevention of fly breeding in dung," at the Department of Agricultural Biology, College of Agriculture, Seoul National University, Suwon, Korea; A10-ENT-12, "Laboratory study of tick repellents and acaricides," at the Veterinary Institute, Beit Dagan, Israel; S9-ENT-7, "Investigations on natural enemies of ants," at el Centro de Investigaciones de Fruticultura, Horticultura y Vitivinicultura, Montivideo, Uruguay; and F4-ENT-6, "Studies on the control of house flies and mosquitoes by means of chemosterilants in Egypt," at the University of Cairo, Cairo, Egypt.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 39.4 professional man-years is devoted to this area of research.

PROGRESS USDA AND COOPERATIVE PROGRAM

A. Basic Biology, Physiology, and Nutrition

1. Mosquitoes, sand flies, and gnats. At Gainesville, Fla., studies are being conducted to obtain biological information needed to accurately evaluate the potentialities of chemosterilants against mosquitoes. Data obtained recently indicate females of Culex pipiens quinquefasciatus may mate more than once if confined with large numbers of males. However, sperm from second matings is utilized only if the matings occur within a few hours of each other. Normal males have been found capable of mating with 2 females per night. Males sterilized with apholate can mate with only about 1 per night.

Additional information has been collected on the action of P^{32} in mosquitoes. Tests have shown that Anopheles quadrimaculatus larvae pick up more radioactivity when exposed to P^{32} in distilled water than infusion water. Increasing the dosage and exposure time increased the activity in the insects but also increased the mortality that occurred. There is a direct relationship between P^{32} activity in the male and the amount found in females inseminated by these males.

At Lake Charles, La., studies were continued on the biology of salt marsh and rice field mosquitoes. Tests were continued with screened and unscreened enclosures. Initially, it appeared that most of the eggs had hatched by the end of the first year. By then, the hatch of eggs was smaller in the screened enclosures than in the unscreened ones. However, during the second year some hatching of Aedes sollicitans, A. taeniorhynchus (2 salt-marsh mosquitoes) and Psorophora confinnis (major rice-field species) continued, even on the 28th flooding. A comparison of eggs laid in the spring and fall suggests that warm weather species A. taeniorhynchus and P. confinnis, especially the latter, lay some egg batches in the late fall. Most of the fall eggs are in a deep diapause state and are less hatchable than eggs laid in the spring. Apparently A. sollicitans eggs do not diapause in the Gulf Coast region; no hatching differences were noted between spring and fall eggs with this species. Ninety-three water samples were analyzed from habitats of salt-marsh Aedes spp. and P. confinnis. Salt concentrations that produced confinnis averaged one-third to one-half as many as those that bred A. sollicitans and A. taeniorhynchus. No pH correlation was noted. In 24 oviposition preference tests, P. confinnis showed a preference for low salinity compared with A. sollicitans and A. taeniorhynchus, but all three species showed definite preferences for increasing concentrations of chloride salts. In further tests, the salt-marsh species sollicitans and taeniorhynchus showed no preferences among chloride salts, but sollicitans avoided sodium carbonate and sodium bicarbonate and these salts were detrimental to sollicitans eggs. Sollicitans eggs hatched in water with a sodium chloride concentration as high as 6.6%. A. taeniorhynchus eggs hatched in water containing as much as 2.0% chloride and P. confinnis eggs hatched at 1.0% chloride.

At Corvallis, Oreg., research continued on the biology of mosquitoes. Aedes dorsalis and A. melanimon are difficult to separate taxonomically. The

same situation occurs with Aedes excrucians and A. aloponotum. It is possible that differences within these complexes may be physiological and due to the habitat. An attempt is being made to establish a colony of A. dorsalis and field sites have been chosen for ecological studies of larval requirements or preferences of dorsalis and melanimon. A seasonal decline in concentration of alkali metals in the water samples from these sites was noted, but further studies will be needed before any conclusions can be drawn. In further biology observations, it was noted that larvae of Mansonia perturbans either develop unevenly or the egg-laying season extends over a considerable period. Aedes increpitus is a fall species; the earliest recorded brood occurred in October, before any killing frost. Thus, exposure to freezing is apparently not a hatching requirement. The commonest species of mosquito breeding this year in log ponds was Culex peus, with lesser breeding of C. p. pipiens, C. tarsalis, and Culiseta incidens in most localities. However, Culiseta incidens was the dominant species at one rural locality and the proportion of pipiens was higher in the urbanized community of Eugene, Oreg., than in more rural settings. A factor in undefatted liver is toxic to larvae of Culex tarsalis. Extracting fat solubles yields a product suitable for larval food.

Captures of insects feeding on a horse showed black flies biting all day long, but highest catches in the late afternoon. Culicoides gnats were most numerous in the morning. Anopheles freeborni, Culiseta inornata, and Aedes dorsalis fed during the day. Studies were initiated to determine which Oregon species of Culicoides gnats feed on poultry.

Research has continued under two contracts at the University of Southwestern Louisiana and McNeese State College. Mosquito breeding was light around Lafayette, Louisiana, particularly in the last half of 1966, compared to previous years. The same situation occurred around Lake Charles, La. Several heavy broods of larval mosquitoes failed to produce comparable populations of adult mosquitoes, suggesting some biological control agent was at work attacking the larvae.

Research was initiated under a grant to Virginia Polytechnic Institute at Blacksburg, Va., on the biology of Culicoides gnats. Initial studies indicate that man is more attractive than small mammals or birds and that the standard New Jersey light trap (used for mosquitoes) and an animal-baited trap, designed by the Principal investigator and a fellow scientist, were the best of several designs tested for trapping these gnats.

Research was initiated under a grant at Louisiana State University, Baton Rouge on the determination of host animals of mosquitoes in certain areas of Louisiana. Blood was collected from species of birds, mammals, amphibian and reptiles. Antisera were prepared and tested for specificity for all animals collected. Preliminary results indicated that of 8 mosquito species collected in 4 parishes the majority had obtained blood meals from beef, a few from horses or swine, and occasionally from rabbits and deer. A few had fed on two hosts.

2. House flies (All Livestock). At Corvallis, Oreg., research continued on the genetics of house flies. The inheritance of resistance was determined by crossing according to standard genetic procedures. Resistance to organophosphates and carbamates was linked to the 5th chromosome semidominant genes. Chlorinated hydrocarbon resistance was associated with these genes and with 2nd chromosome recessive genes. Resistance to the cyclodiene group of hydrocarbons was associated with a gene or genes other than the 2nd and 5th chromosome genes. Noninsecticidal carbamates were found in some instances (nearly 200 tested) to synergize carbamate and organophosphate insecticides. In one instance, resistance was reduced from 300-fold to 5-fold or less by the combination. The results support the hypothesis that different alleles of the same major gene confer resistance to carbamates and organophosphates in the house fly.

3. Stable Flies (Cattle and Horses). In Oregon, colonies of stable flies were maintained on varying numbers of blood meals per week. One colony which has existed for six generations on three blood meals a week now oviposits as well as a colony fed five blood meals a week. Another colony was maintained with two and five blood meals a week given to alternate generations.

In Texas, in cooperation with the Agricultural Engineering Research Division, a system for recording stable fly flight activity was constructed. An electrometer probe placed in a fly cage and connected to a recorder continuously records the flight of stable flies under varying conditions.

4. Horn Flies (Cattle). The percentage of female horn flies mated at different ages in a laboratory test conducted in Texas were: 1 day old, 0%; 2 days old, 12%; 3 days old, 63%; 4 days old, 83%; and 5 days old, 89%. Other tests indicate that one male horn fly will inseminate 1 to 6 females over a 7-day period.

An insect bitometer was constructed at the Kerrville, Texas, laboratory in cooperation with the Agricultural Engineering Research Division. The bitometer was used to study the in vitro feeding activity of horn flies. The results of tests conducted under continuous light indicate that horn flies do not tend to feed at a certain time during the day.

In Texas, an improved artificial horn fly larval medium was developed. The medium contains 264 g ground sugarcane pulp, 12 g fish meal (livestock feed grade), 48 g whole wheat flour, and 6 g sodium bicarbonate. The number and size of horn fly pupae produced in this medium equal or exceed the production from cow manure.

Studies were initiated on the biology and ecology of horn flies in cooperation with Mississippi State University, State College, Miss. Differences were found in the sex ratios of field collected horn flies. For example, during March the percentage of males was 56%, while for April through June

it decreased--the range was 34%-47%. Phenomenon of diapause is being studied in environmental chambers. Larval development was extended using 12 hour light with constant temperatures.

5. Horse Flies, Deer Flies, and Snipe Flies (All livestock except poultry). In Mississippi, collection of horse flies from a bait animal indicated the feeding activity is strongly influenced by outdoor environmental conditions. A peak of activity was observed from 8:30 to 9:30 a.m. Secondary peaks tend to occur during periods of highest light intensity. There seemed to be a negative correlation with relative humidity and a positive correlation with dew point. Feeding-landing ratios for eight species varied from 59% for the Tabanus atratus to 5% for T. subsimilis, the most abundant species.

At Fresno, California, in cooperation with the University of California, research was initiated on horse flies, deer flies, and snipe flies. Snipe flies are biting flies roughly resembling deer flies in their manner of attacking man and livestock. Malaise traps baited with carbon dioxide caught numbers of snipe flies that correlated well with numbers collected from tame deer. However, horse flies and deer flies responded better to the traps than to the deer. A trap consisting of rotating nylon nets caught many more horse and deer flies than the Malaise trap. There is a tendency (most pronounced on young deer) for snipe flies to bite or to be allowed to bite on the face rather than the ears.

Research under a grant to the University of Utah was initiated on the biology and control of tabanids in marshlands along the eastern shore of the Great Salt Lake. Six species of tabanid flies were collected in the study area. Chrysops discalis the most abundant and pestiferous species deposited eggs only on vegetation or other objects over water. A total of 11 different plant species were used for oviposition. The adults emerged only from moist soil. The counting of pupal cases on the surface of the soil was a suitable method of determining the number of emerging adults in a given area.

Research is continuing under a grant to the University of Wyoming on the biology of tabanids. A small scale mark-recapture study of Tabanus reinwardtii and Chrysops fulvaster indicated that both sexes of C. fulvaster but only males of T. reinwardtii remained close to flowing creeks whereas marked females of T. reinwardtii were collected on horses 3 miles away. Males of both species are active only during 7 to 10 a.m., while females remain active from 6 a.m. until sunset. Mating of both species was observed many times and motion pictures were made. All mating occurred between 7:30 and 11:00 a.m. at temperatures between 75 and 88° F.

Research under a grant to Louisiana State University was initiated on the determination of host animals of tabanids in certain areas of Louisiana. Blood was collected from species of birds, mammals, amphibian and reptiles. Antisera were prepared and tested for specificity for all animals collected. Preliminary results indicated that of the 7 species of tabanids collected from 6 parishes, the majority had fed on beef, a few on horses, and one each on a rabbit and a deer.

6. Face Flies (Cattle and Horses). At Corvallis, Oreg., a survey was made for the presence of face flies. This survey conducted in the central, eastern, and northeastern sections of the State failed to show the presence of face flies in 1966.

Prior to July 15, 1966, face fly populations were lower in eastern Nebraska than in previous years during the same period. Counts were three flies or less per animal. Numbers increased to 10 or more per animal soon after mid-July and remained high for the duration of the season. Flies began to congregate at overwintering sites during the week of September 19. Some had entered buildings and clustered on September 20, 1966.

Tests in Nebraska showed that face fly larvae migration prior to pupation ranged from 0.5 to 30 feet from the cow dung in which they developed. The distance that the larvae migrated depended on environmental conditions and ground cover. Aleochara tristis larvae, a parasite of face flies, traveled 12 to 14 feet to parasitize face fly pupae.

7. Little House Fly (Poultry). At Corvallis, Oreg., an orange-eyed strain of the little house fly, F. canicularis, was established from progeny of a mutant female observed in the laboratory's stock Fannia colony. Later, a white-eyed strain was isolated from the orange-eyed strain.

Tests on the inheritance of the characters have demonstrated that the orange-eyed condition is inherited as a simple recessive. The white-eyed condition is a modifier of dominance such that flies homozygous for orange eyes and heterozygous for white eyes are yellow-eyed, while flies homozygous for both conditions are white-eyed. Flies homozygous for white eyes but not homozygous for orange eyes are wild type.

The mutants are being used in experiments on the sexual biology of Fannia, and should prove useful in studies on insecticide resistance.

8. Screw-worm (All livestock except poultry). Sterile flies released at the rate of 1000 flies per square mile per week were not effective in reversing a rising trend in screw-worm populations in a 5496 square-mile area in Sinaloa, Mexico. There were indications from the ratios of sterile to fertile egg masses collected from pens of wounded animals that the effects of the released males decreased as a function of distance within 2 to 3 miles from the line of release.

The seasonal cycle of screw-worm activity in Sinaloa followed much the same pattern previously noted on the east coast of Mexico, i.e., peak populations in the spring and fall and relatively low populations coinciding with dry weather in summer.

In cooperation with the Department of Agriculture of Mexico, trapping studies in a deep, narrow canyon in western Mexico indicate that sterile flies will

disperse into canyons of this type after having been released over mountainous terrain at altitudes up to 12,500 feet.

Studies were continued on the possible changes in longevity, fecundity, and behavioral characteristics of screw-worm flies as a result of adaptation to artificial rearing and holding procedures. The mean longevity of wound-reared females of a recently introduced Mexico strain was 28.5 days as compared to 21 days for females of this strain reared on artificial medium. There was no statistically significant difference in longevity attributable to sex. Flies of the Mexico strain lived longer than flies of the older Florida strain. Females of both the above strains reared from artificial medium were less fecund than females reared from wounds, and the average eggs per egg mass was more variable in the former group. There was no evidence that selection for adaptation to artificial medium had affected fecundity in either strain. Wound-reared Florida strain flies previously reared on artificial medium for over 150 generations laid an average of 352 eggs per egg mass compared to an average of 344 for Mexico strain females from a stock that had been reared exclusively on wounds.

Tests are being continued to determine the minimum size range for male screw-worm flies without impairment of physical ability to mate with wild type females. Males from prepupae weighing less than 50 mg mated 51% of the available populations of wild type females compared to 79% for males from prepupae weighing 60 to 70 mg.

The time required for screw-worm larvae to obtain the capacity to pupate varied from 52 hr on artificial media to 94 hr on wounds. The critical larval weight for successful pupation ranged from 26 to 30 mg. Pre- and postcritical growth curves are being used to evaluate the suitability of various artificial media.

A new device for permitting free oviposition by mated female screw-worm flies is yielding data on potential egg production from field populations of flies. The rate of egg mass depositions as a function of local population densities is needed for the interpretation of the results of field studies.

The longevity of laboratory-reared screw-worm flies was determined by recording the daily mortality of bisexual and unisexual populations and of solitary flies. Males and females in unisexual populations outlived those in bisexual populations, an indication that an adverse effect on longevity was produced by the interaction of the sexes. Solitary males and females outlived males and females in unisexual populations, an indication that an adverse effect on longevity was produced by grouping the flies. Females outlived males when the two sexes were segregated or when the flies were solitary, but this difference was largely masked when the sexes were mixed.

When screw-worm flies were released and observed for 10 days in a laboratory room, survival of females and fertility were improved when the tile floor was covered with cheesecloth. The cheesecloth probably provided a more

secure footing for the flies than tile so that more matings were successfully terminated than were interrupted prior to completion.

Although egg production was similar for 5-, 10-, and 15-day-old female screw-worm flies, the fertility of eggs laid by 5-day-old females was greater than that of 10- and 15-day old females, which was equal.

When 7-day-old females from bisexual populations were weighed and allowed to oviposit individually, the relationship between body weight and the number of eggs laid was linear. For each additional milligram of body weight, the number of eggs laid was increased by an average of 4.5 eggs.

Tests on hydroponic media for screw-worm larvae were conducted in cooperation with the Animal Health Division at Mission, Texas. Dehydrated food-stuffs were compounded into hydroponic type media for rearing larvae of screw-worm. Mixtures containing whole blood, calf suckle, and whole egg supported larval growth and development equal to regular media of fresh meat and blood.

9. Cattle Grubs (Cattle). At Kerrville, Texas, it was found that during the pupal period of Hypoderma bovis, weight and specific gravity decreased rapidly in days 0 to 4, and after that the decrease was gradual. Volume of the pupae decreased slightly during the 22.6-day period for females and 21.5 day period for males. Oxygen consumption followed the characteristic "U"-shaped curve, with lowest levels at 6 to 8 days after larvae had egressed from animals' backs.

At Corvallis, Oreg., Hypoderma bovis pupae that were held in the laboratory emerged approximately 15 days earlier than field-reared specimens. Survival of the puparia reared in the laboratory was nearly 10% greater than those reared in the field. Sex ratio for both field and laboratory specimens was 50%.

A study of cattle grub morphology was conducted at the Kerrville, Texas, laboratory in cooperation with Purdue University. Studies of the three larval instars of Hypoderma lineatum indicate that there is a complete digestive tract in all instars. It consists of a pharynx, esophagus, ventriculus, intestine, and rectum. Malpighian tubules were identified in all larval stages. The respiratory system consists of functional paired anterior and posterior spiracles with connecting tracheae and tracheoles.

10. Ticks (Cattle). A laboratory colony of Dermacentor albipictus has been established at Kerrville, Texas. All parasitic stages were raised on bovine in a stanchion. Over 2600 engorged females were recovered from one calf. Engorged females weighed an average of 0.42 to .5 g; preoviposition period is 10.8 days; oviposition period is 23.2 days; average egg mass contains 3600-4200 eggs.

The ticks, Boophilus annulatus and B. microplus were cross-mated under controlled conditions and the females of both species produced fertile

eggs. Brother x sister crosses of F_1 hybrids indicated that most of these progeny are sterile; back crosses of F_1 hybrids to pure strain annulatus and microplus indicated there is much more sterility in hybrid males than females. Some fertile hybrids were produced in 2 of 16 crosses of microplus ♂ x annulatus ♀.

11. Mites (Poultry). Research continued on the biology of Neoschongastia americana, a mite, which is a serious pest of turkeys, under a grant at the University of Georgia. The mites showed no preference as to either sex or age of turkeys. Mite population cycle peaks occurred at two-week intervals. A lesion is started by one mite and others are apparently attracted by secretions from the initial wound, which are located on the inside and outside of the thighs and only rarely on the breast. Lesions caused by mites feeding reached a point beyond which the lesion was incapable of supporting mites.

B. Insecticidal and Sanitation Control

1. Mosquitoes. At Gainesville, Fla., the search for new and safer insecticides for mosquito control was continued. The most effective materials screened against larvae of Anopheles quadrimaculatus were experimental compounds ENT-27386 and ENT-27444 which gave 100% control at 0.01 ppm. Five other commercial compounds killed all of the larvae at 0.025 ppm.

Comparative tests conducted with the standard larvicide technique have shown Dursban and Abate to be two of the most efficient larvicides that have ever been developed for the control of Aedes taeniorhynchus. They have been 2 to 3 times better than parathion, the most effective compound tested previously and considerably more effective than fenthion, malathion, naled, or DDT. In wind-tunnel tests against adult mosquitoes, six insecticides were evaluated that appear to be as effective as the malathion standard. Eleven synergists have also been found that increased the toxicity of Bay 39007 at least 2 times.

The development of ultra-low-volume sprays has received major attention at the Gainesville laboratory. Of the materials tested so far naled, fenthion, and Bay 39007 have proven to be more effective than malathion. A comparison of ultra-low-volume and conventional sprays showed naled to be about equally effective in both types of application. Fenthion, however, was about 20% less effective as an ultra-low-volume spray than as a conventional spray 6 hours after application, but both methods of application caused about the same reduction after 24 and 48 hours. Malathion was slightly less effective as an ultra-low-volume spray than as a conventional spray regardless of the time interval after treatment.

Bay 39007 has been found more effective than malathion as an aerial fog against natural infestations of adult salt-marsh mosquitoes, Aedes taeniorhynchus and A. sollicitans in Florida.

Additional research has been conducted with a nonthermal aerosol generator developed to disperse insecticides from the ground. Fenthion, naled, Bay 39007, Bay 41831, Schering 34615, Dursban, and Shell SD-8211 and an experimental compound, ENT-27334, have been highly toxic to adult females of Aedes taeniorhynchus, Anopheles quadrimaculatus, and Culex pipiens quinquefasciatus in tests with this equipment. When thermal and nonthermal aerosol applications of DDT and malathion were compared, the two pieces of equipment produced similar mortalities. DDT at 16% was ineffective against Aedes taeniorhynchus and Culex pipiens quinquefasciatus but produced 89 to 100% mortalities of Anopheles quadrimaculatus. Malathion at 4% produced 64 to 99% kill for 300 feet against all 3 species.

Larval selection with DDT for nine generations increased the resistance in a strain of Anopheles quadrimaculatus, that was already known to possess some resistance, to a level that was 2,333 times above that of the laboratory colony and 152 times above that of the parent strain. Adults of this strain exposed on panels treated with insecticides showed resistance to DDT >10,000 times higher than the regular strain of Anopheles quadrimaculatus but were nonresistant to malathion.

Studies are still in progress to develop new insecticides that can be used as residual sprays where Anopheles mosquitoes have become resistant to DDT and dieldrin. In laboratory tests 6 chemicals have been sufficiently effective to justify testing in buildings naturally infested with mosquitoes.

Research was continued at Corvallis, Oreg., on the evaluation of insecticide resistance and the development of insecticides. Resistance to DDT was demonstrated in Culex tarsalis at Oakridge, Oreg., 10 years ago. Although DDT has been used little or not at all for mosquito control there since, the resistance persists. It could be reasoned that some selective factor probably is present that favors the resistant strain. Most probably this is continued use of various larvicides; thus, pressure must be supposed on the DDT-resistance gene. Abate, Dursban, and fenthion are all highly effective against mosquitoes resistant to DDT and malathion in a laboratory strain of Culex p. pipiens. Larvae of Mansonia perturbans showed high tolerance to malathion and DDT and a surprising amount of tolerance to fenthion, with some evident even to Dursban and Abate. These appear to be natural tolerances.

Abate and Dursban are two of the most promising mosquito larvicides. Last year's tests gave little residual larvicidal action at the low dosages tested; slightly higher dosages (0.06 lb Abate/acre and 0.035 lb Dursban/acre) gave averages of 13 days and 18 days protection, respectively for the two materials.

Eighty-four compounds were evaluated as repellents and toxicants for wild Aedes dorsalis mosquitoes in spot tests on cattle. Three of the compounds had shown promise in 1965; they again showed good repellency for several days.

About 3 dozen potential systemic insecticides were tested. Most interesting were the results obtained with tests in which 6 insecticides were given orally to cattle. All caused some mortality of Aedes aegypti feeding on the treated cattle. The best were trichlorfon and famphur, which gave 98 and 100% kill, respectively, at the highest dosage tested. Another interesting finding in these tests was that stable flies were more susceptible than mosquitoes. Several compounds ineffective against mosquitoes also killed stable flies.

Research was continued under contract with the University of California to evaluate promising insecticides for mosquito control in low-volume applications. Promising results were obtained with low-volume applications of fenthion and Dursban. Mosquito control in pastures was usually 100%, but results were less effective in dense plantings of rice fields until the airplane nozzles were pointed forward, reducing droplet size and apparently increasing penetration.

Research was conducted under cooperative agreement with the University of Florida to study the genetic basis of resistance to chemosterilant by a mosquito. Chemosterilant dosages are being explored as a prelude to genetic tests.

2. House flies. At Gainesville, Fla., the search for new insecticides effective in controlling house flies was continued. In laboratory tests, 5 experimental materials were more effective than the ronnel standard against insecticide susceptible and resistant house flies. Residual tests against house flies in Florida dairy barns were conducted with 9 insecticides. Dimethoate and fenthion were the most effective, but they produced more than 50% control for only 3 to 14 days.

Research was continued at Corvallis, Oreg., on the development of insecticides and the evaluation of insecticide resistance. The resistance spectra of 8 strains of house flies were measured in tests with 13 insecticides (organophosphates, carbamates, chlorinated hydrocarbons, and pyrethrins). Some strains were resistant only to a limited number of insecticides, others were resistant to most materials tested.

In other studies with a parathion-resistant strain of house flies, increased tolerance occurred to phosphates containing O-methyl esters, but lesser tolerance to phosphates containing di-n-propyl or diisopropyl esters. Exposure of malathion-resistant house flies to malathion synergized with DEF (S,S,S-tribuytl phosphorotrithioate) resulted in increased resistance. However, the increase in resistance was only 5-fold in 29 generations, suggesting that combinations of organophosphates and synergists or use of O,O-dialkyl phosphates show promise for control of flies resistant to standard phosphate insecticides.

Commercial 20% dichlorvos resin strips were found to be highly effective on larvae of flies breeding in sewage pits at a slaughter house. Mortality of

larvae was complete within 5 days and some reduction in fly breeding continued another week, even after removal of the dichlorvos resin strips.

At Beltsville, Md., investigations of physical methods for fly control were continued in cooperation with the Animal Husbandry and Agricultural Engineering Research Divisions. Research on the effectiveness of farmstead sanitation confirmed previous findings that significant house fly reductions (about 33%) can be achieved by sanitary measures on a single farm when unsanitary farms are close as 1/2 mile. Flies dispersed primarily upwind and to "dirty" areas with many potential breeding sites, rather than to "clean" areas.

Research was conducted under cooperative agreement with the University of Florida to study house fly insecticide resistance. Continuous exposure was found to be the simplest method of determining resistance in house flies.

3. Screw-worm (All livestock except poultry). Of 15 compounds tested at Mission, Texas, as larvicides against newly hatched screw-worm larvae at three concentrations, 10, 1.0, and 0.1 ppm, in the larval medium, 8 were highly effective, killing all of the larvae at 1.0 ppm. Four of the compounds screened were effective at 0.1 ppm.

4. Stable Flies (Cattle and Horses). In Texas 211 new compounds were screened in spot-tests on cattle for repellency and toxicity against the stable fly. Seven of these compounds were Class IV toxicants at concentrations of 0.5% or lower. One compound was a Class IV feeding repellent, due to its rapid knockdown action.

Large cage tests were conducted to evaluate two chemicals for the control of stable flies. Conventional 2-qt spray applications of 0.25% Dursban and 0.25% of an experimental compound, ENT-27405, were effective 3 to 10 days against stable flies.

In Oregon, six systemic insecticides were administered orally to cattle to determine their relative toxicity to stable flies and mosquitoes. Stable flies were more susceptible to the insecticides than mosquitoes, except for famphur where little difference was noted. Fenthion and famphur were more toxic to insects at lower dosages than the other materials tested. The longest lasting material was an experimental compound, ENT-22377, which caused mortality of the insects for two or more weeks.

Research continued under contract with the Florida State Board of Health at Panama Beach, Fla., on control of dog flies (stable flies). Naled continues to look promising as an adulticide, but DDT is the most effective larvicide applied to beach grasses where these pests breed. Bay-39007 appears to be about as effective as DDT for this use. DDT is relatively ineffective against adult flies. Bay-39007 is about as effective as DDT in the beach grass piles.

5. Horn Flies (Cattle). In Texas, large cage tests were conducted to evaluate two chemicals for the control of horn flies. Conventional 2-qt spray applications of 0.25% Dursban and 0.25% of an experimental compound, ENT-27405, were effective for 15 to 18 days.

Two herds of cattle at Camp Stanley, Texas, were sprayed with 2 qts/head of 0.25% Shell SD-8447 for horn fly control. The compound provided less than 13 days control.

An automatic sprayer for ultra-low-volume (ULV) application of insecticides (1-ml per application) to cattle has been developed in cooperation with the Agricultural Engineering Research Division. Laboratory studies indicated that the following concentrations of insecticides would be required to maintain horn fly control on animals utilizing the ULV sprayer on a daily basis (1-ml applications twice daily): carbaryl 1.0%; Ciodrin 0.5%; Compound 4072 0.25% or 0.1%; coumaphos 0.25%; malathion 1.0%; and methoxychlor 1.0%. Milk residue studies with 2% and 5% malathion resulted in no residues in the milk. Ronnel at 5% concentration resulted in a maximum residue of 0.014 ppm and at 10% a maximum residue of 0.037 ppm. Field tests demonstrated that ULV sprayers will control horn flies on dairy herds, using 0.5% Ciodrin spray.

At Kerrville, Texas, tests indicate that horn flies resistant to ronnel may have increased tolerance for coumaphos, trichlorfos, Shell SD-8447, dioxathion, malathion, and bromophos.

Two insecticides were tested against the larvæ of a ronnel resistant strain of horn flies and a ronnel susceptible strain of horn flies. The larvae of the ronnel resistant strain showed a high tolerance for both ronnel and Dowco 177.

In Texas, bioassays were run to determine the toxicity to horn fly larvae of manure from cattle fed three insecticides at varying rates for 10 days. All the materials reduced larval survival but only famphur at 5 mg/kg daily gave 100% mortality.

A component in the water insoluble (pH 7.0) fraction of Bakthane, a commercial product of Bacillus thuringiensis, was responsible for the activity against horn fly larvae in feces from cattle treated orally. Larvicidal activity was found after oral treatments with separate spore and crystal fractions; however, minute amorphous particles from the parent material remained with both spores and crystals after separation.

In Mississippi, field tests were conducted for the control of horn flies, using five methods of application and six insecticides. Control was obtained with the insecticides applied in dust bags, back rubbers, as water based sprays, as oil-based sprays, and as pour-ons. Most treatments afforded excellent horn fly control.

Research was initiated under cooperative agreement with the Delta Branch Experiment Station, at Stoneville, to determine the efficacy of insect

control on cattle as related to beef production. Preliminary data from the initial tests of this long term study indicate that the techniques being tried had a detrimental effect on weight gains.

6. Cattle Grubs (Cattle). In Oregon, Imidan as an 0.375% spray proved highly effective in reducing cattle grub numbers. However, Imidan provided poor control when sprayed at 0.25%. Imidan at 5 g/hd as a pour-on was highly effective. Two other compounds tested showed systemic activity but even at the highest dosages tested, activity was lower than desired.

Research was continued in Texas and Oregon to develop more effective insecticides for the control of cattle grubs and other bots affecting livestock. At the Kerrville, Texas, laboratory 55 new compounds were screened for systemic action by giving them orally and subcutaneously at several dosages to guinea pigs infested with larvae of Cochliomyia macellaria and Phormia regina. Stable flies and nymphal lone star ticks were also allowed to feed upon the treated animals. Twenty-four materials exhibited systemic activity in one or both types of administration.

In Texas, 43 systemics were tested for effectiveness against cattle grubs (H. lineatum and H. bovis) on both native and imported Wyoming cattle. Each treatment group consisted of small numbers (3 to 4) of these government-owned cattle. Materials considered effective were those providing 90% or greater control of cattle grubs. In these tests, three were effective as sprays alone, one as a spray and in the feed, one as a pour-on, one in the feed materials, and two in oral capsules. In large scale tests on cooperator-owned cattle, 74 and 79% control of grubs was obtained with 0.05 and 0.1% sprays of fenthion, respectively, and a 2% pour-on of fenthion applied at 1/2 oz/cwt provided 76% grub control.

7. Nose bots (Sheep and goats). Basic studies on the nature and significance of the mode of action of systemic insecticides against sheep nose bots when administered to sheep by different routes was conducted under a grant to the University of Kentucky. Thirty-two lambs were artificially infested each with 25 1st instar larvae of the sheep nose bot. Six compounds were administered in capsule form at one mg/kg per day for a 10-day period. Four days later the animals were sacrificed and examined. Fenthion and famphur killed all the 1st three instars of larvae of the sheep bot.

8. Ticks (Cattle and Horses). During the early summer of 1966, two tests were conducted at Camp Stanley, Texas, with 2-year-old Hereford heifers naturally infested with lone star ticks to evaluate the efficacy of insecticidal sprays in controlling these ticks. Bromophos-ethyl, Bay 39007, Imidan, Dursban, and Banol were applied to cattle at various concentrations in different formulations (1 gal/hd) and the effectiveness in controlling lone star ticks was compared to a standard 0.5% toxaphene spray. All treatments, except bromophos-ethyl (0.25%) and Dursban (0.01%), were as effective as toxaphene (0.5%) in controlling ticks at one day posttreatment. At one

week posttreatment, only 0.1% Bay-39007 and 0.01% Dursban were as effective as 0.5% toxaphene. In general, at two weeks posttreatment, numbers of ticks on treated cattle were equal to numbers on untreated cattle.

Personnel at the Kerrville, Texas, laboratory continued research on the evaluation of insecticides for the control of Boophilus ticks on cattle. Of 87 insecticides used in screening tests to determine activity against Boophilus annulatus and/or Boophilus microplus, only 12 were placed in Class IV (effective at 0.01%). Materials considered effective were those that reduced egg laying or egg hatch by at least 90%.

Field tests were also continued in Mexico to evaluate the effectiveness of promising insecticides as sprays and dips for the control of Boophilus ticks on cattle. Sprays of 0.03% coumaphos EC (as Asuntol); 0.01% and 0.03% coumaphos EC (as Co-ral); 0.5% Mobil MC-A-600; 0.25% Banol; 0.1% Bay-39007; 0.15% Clodrin; 0.06% coumaphos WP; 0.5% menazon; 0.05% diazinon; 0.075% dioxathion; 0.03% coumaphos WP; and 0.5% carbaryl gave 96 to 99.95% control of reproduction. Dipping trials with Dursban, Shell SD-8447, and carbaryl provided high or complete control of reproduction. Dursban that had been allowed to age for nine months in the vat, still provided greater than 99% control of tick reproduction. On the other hand, Shell SD-8447 at six weeks failed to control ticks due to the formulation combining with dirt, debris, etc., and settling to the bottom of the vat.

In Texas, 16 formulations of 11 insecticides were applied to the ears of 35 cattle for control of the ear tick, Otobius megnini. Only the following afforded $\geq 94\%$ control of nymphs at 1 month posttreatment: Coumaphos 4% pour-on, 5% dust, and 0.25% in aerosol with 0.5% trichlorfon; and Dursban 0.1% emulsion.

A technique has been developed at the Kerrville, Texas, laboratory in which cattle are used as hosts for the tropical horse tick, Anocentor nitens. A large number of engorged females have been raised for laboratory insecticide tests. Testing procedures similar to those used to determine the effectiveness of insecticides for the prevention of reproduction of Boophilus ticks have been used to obtain similar data for A. nitens. Of 65 compounds tested for ixodocidal activity against A. nitens, 23 were effective at a concentration of 0.01%.

The Kerrville laboratory has also established a colony of the winter tick, Dermacentor albipictus, by raising all parasitic stages on bovines in a stanchion. Engorged female D. albipictus were dipped in 30 insecticides by techniques developed for Boophilus screening tests. Compounds placed in Class IV (effective at 0.01%) were: Lindane, isobenzan, Shell SD-8448, and experimental compounds ENT-24967 and ENT-25869.

Research on insecticidal methods of controlling ticks was continued at Gainesville, Fla. In a field test Bay-39007 was highly effective as a toxicant against a natural infestation of fowl ticks, Argas persicus in a

commercial poultry house. Reductions of 99 to 100% were obtained for at least 193 days with a spray containing 2.5% Bay-39007, for 109 days with 1% Bay-39007, and 81 days with 0.5% Bay-39007.

Research was continued under PL-480 with the Ministry of Agriculture at Beit Dagan, Israel on tick repellents and acaricides. The ortho isomer of deet (N,N-diethyl-ortho-toluamide) was toxic and repellent to Hyalomma excavatum and repellent to Rhipicephalus secundus ticks. Ortho-deet was about 10 times more repellent than dimethyl phthalate. Dimethyl phthalate showed no toxicity (acaricidal effects) to ticks at the dosages tested. Preliminary tests indicate oil of Citronella is about one-tenth as acaricidal and benzyl benzoate is about one-fifth as acaricidal as ortho-deet to ticks.

9. Lice (Poultry). In Kerrville, Texas, louse populations on leghorn hens were eliminated by dusting with 4 g/bird of a commercial preparation of Bacillus thuringiensis containing spores, crystals, and toxins. Four to five weeks were required for complete control with a single dusting; multiple treatments reduced the control time to about three weeks.

Thirty-one selected toxicants were evaluated for control of poultry lice by 40-ml direct spray to the bird treatments of 0.25% or less concentrations. Twenty-nine of the toxicants eliminated all motile forms of lice on the birds in seven days or less. Ciodrin was outstanding and gave complete control at a concentration of 0.025%.

Direct application in spray tests of an experimental compound ENT-27395 eliminated Northern fowl mites from hens at a concentration of 0.1%. Litter treatments with Shell SD-8447 at a rate of 1 lb/100 ft² eliminated poultry lice, but not at 0.5 lb/100 ft².

C. Biological Control

1. Mosquitoes. At Gainesville, Fla., research on pathogens of mosquitoes has been continued. Larvae of Anopheles quadrimaculatus and Aedes aegypti exposed to Nosema spores became heavily infected. The A. quadrimaculatus were more susceptible than A. aegypti to the disease. Primary sites of infection are the fat body, gut, and malphigian tubules. Stempellia magna has been found infecting larvae and adults of Culex restuans. A new species of Stempellia has been found in Culex pilosus. Both species are transmitted transovarially and cause high mortality in larvae. Attempts to transmit them per os to other mosquitoes have failed so far. Thelohania legeri has been found in two Anopheles spp. in Florida and its life history is being studied in the laboratory. Stages of the pathogen have been found in late instar larvae, pupae, and female adults but have not been observed in first instar larvae. Thelohania opacita was found in Culex territans.

Coelomomyces fungi have been found in the larvae and adults of Anopheles crucians. In one test Coelomomyces fed to early first instar larvae of

A. quadrimaculatus resulted in heavy infections in several specimens. A fungus of the genus Rubettella was found in the larvae of two Culex spp.

Two types of Mosquito Irridescent Virus have been obtained from larvae of Aedes taeniorhynchus. One caused the larvae to be an iridescent pinkish color, and the other produced a bluish-green color. Both types have been transmitted to the first and second instars of Aedes taeniorhynchus in the laboratory. These infections produced approximately 10% mortality. The adipose tissue appears to be the primary site of infection, and as the disease progresses the fat body cells become hypertrophied and eventually rupture, releasing numerous viral bodies into the haemocoel. The viruses have been purified sufficiently to begin electron microscope studies.

At Corvallis, Oreg., research continued on pathogens of mosquitoes. A fermentation product of Bacillus thuringiensis was toxic to larvae of Culex tarsalis, with an LC-90 of about 40 ppm during the larval development period. Toxicity was expressed as failure to survive and emerge as adults. A major problem in use of pathogens is the lack of methods to infect a field population of mosquitoes with the pathogen. Excystation of Thelophania spores can be induced with exposure to gaseous osmic acid, or exposure to oxygen followed by desiccation over calcium chloride. Osmic acid was found to be toxic to Culiseta incidens larvae. Oxygenation was more effective in spores frozen and held at 4° C. for about 8 months than with spores kept at room temperature for the same period.

At Lake Charles, La., research on mosquito pathogens as potential biological control agents continues to receive increasing emphasis. Microsporidian (and other protozoan), bacterial, fungal, viral, and nematode parasites continue to be found in various species of mosquitoes. Colonies of the following mosquitoes have been developed and are being maintained (the note in parentheses indicates a regular strain and one harboring the type of pathogen listed): Aedes aegypti (virus), A. taeniorhynchus (virus), A. tormentor (Thelohania, a microsporidian), A. triseriatus (Thelohania), Culex salinarius (Thelohania), C. pipiens quinquefasciatus (Plistophora, another Microsporidian), Culiseta inornata (Plistophora), and Psorophora ferox.

Protozoan pathogens have been found in 17 species of mosquitoes and include 3 genera of microsporidia and 1 genus of flagellate. One, the Plistophora in Culiseta inornata, has been maintained in the laboratory through 10 generations of mosquitoes. It is transmitted transovarially.

A bacterium, probably a species of Vibrio, was found in three species of mosquitoes and was transmitted to larvae of two other species of mosquitoes in food.

Fungal infections were found in 9 species of mosquitoes. Some kinds were readily transmitted to other mosquitoes in the laboratory.

At least two species of virus infecting mosquitoes have been found, and 4 species of mosquitoes have been found to be hosts. One virus has been maintained in the laboratory through 62 successive generations. This virus is readily transmitted to another mosquito species and back to its parent species. However, the other virus is readily transmitted to its host species, but to only one percent of a second species of mosquito.

Nematodes were observed in 6 mosquito species. Over 90% of some Aedes sollicitans populations were found to be infected in nature. The nematode in this mosquito is believed to be Agamomermis culicis, reported early in this century but not fully described. It causes the death of many female mosquitoes, and those that survive are unable to lay eggs in normal numbers.

The fact that all of these mosquito pathogens have been found in the field may cast some doubt on their potential usefulness at this time in controlling mosquitoes naturally present in Gulf Coast marshes. However, they may be a principal factor holding mosquito populations in check in "light mosquito years." Further research may show how to increase the efficiency of the pathogens to prevent "heavy mosquito years."

Research was continued under a contract with the California State Department of Health at Fresno to study pathogens affecting mosquitoes. A polyhedral virus was found in a field population of Culex tarsalis. The fungus Beauveria bassiana kills mosquitoes in laboratory tests, but results were disappointing in simulated field tests. Attempts are being made to increase its virulence, or improve the method of infecting mosquitoes. Mosquito infections with protozoa (Stempellia and Plistophora) are also being studied.

Research was initiated under a grant to the University of California at Riverside on the use of introduced annual fishes as a means of mosquito control. Early studies with the fish Cynolebias bellottii, C. wolterstorffi, and Nothobranchius guentheri indicate C. bellottii is the most promising, at least for California conditions. Eggs are laid even at temperatures near freezing and withstand 10 weeks burial in mud. Development to maturity requires about three weeks after hatching of the eggs.

Research has continued under contract with McNeese State College at Lake Charles, La., on predators and parasites of mosquito larvae. Collections of arthropods were made and identified in the hope of finding good control agents. Corixid bugs and Cyclops (crustacea) did not appear in laboratory tests to be predaceous, though this is reported in the literature. Three types of native minnows consumed large numbers of mosquito larvae (up to a hundred or more per fish per day) and these studies will be continued.

2. House Fly. Research also continued in Korea with dung beetles under PL-480. Several species have been found that are easy to rear, and some progress has been made in learning which species most efficiently renders manure unsuitable for fly breeding. A grant to the University of California is showing excellent progress on the effects of manure removal schedules on

population dynamics of immature stages of six species of filth flies and on their predators. Biweekly sampling continued all year to determine annual cycles of abundance for the fauna of the manure. Wood shavings under the manure increased the abundance of predaceous beetles but not the mite or maggot population with the possible exception of *Stomoxys*. In the laboratory the mite Macrocheles was found to prey on eggs of Stomoxys, Ophyra, Fannia, and Muscina.

3. Imported Fire Ant. Under PL-480 support, research was continued on parasites of the imported fire ant in Uruguay. Studies with the parasitic ant, Labauchena daguerri continued. This ant is quite effective in decimating and ultimately eliminating colonies of the imported fire ant, but the major objective of present research, how to spread the parasite ant, has not yet been reached. Progress was made in overcoming the resistance of imported fire ants to artificial infestation with Labauchena, promising that an effective method may be found. Two other potential parasites, a mite and a beetle have also been found.

4. Face Flies (Cattle and Horses). At Lincoln, Nebr., Aleochara tristes, an imported parasite-predator of the face fly, and A. bimaculata, a native species, utilize the same habitats in Nebraska pastures and apparently compete for food. A host preference study indicated the order of preference for tristes is face fly, Orthellia caesarion, house fly, stable fly, and horn fly. In the case of bimaculata, the face fly was the least preferred of four dipterous hosts.

Two adults of A. tristes, an imported Staphylinid, were collected from a Nebraska pasture in the spring of 1966. Over 40,000 adult beetles were released in this pasture in the summer of 1965 but adults were not found in October and November. The 1966 collections prove that the species is able to overwinter in nature under Nebraska conditions.

A nematode parasite of the face fly, previously reported from New York, was found in hibernating face flies near Lincoln. In one collection, 34% of the female and 21% of the male flies were infected. Infected females may develop and deposit their first batch of eggs. Rapid multiplication of nematodes in the fly's abdomen prevents further reproduction of the fly. Infested flies, 9 to 16 days old, were able to pass nematode larvae that became infective.

Research was initiated under a grant to Virginia Polytechnic Institute on the effect of native parasites on the natural regulation of face fly populations. Manure that had been artificially infested with laboratory-reared face fly larvae were exposed to native parasites and predators. These preliminary studies showed over the summer an average of 55.6% predation of face fly larvae at Warm Springs, Va., and 45.6% and 48.6%, respectively, at two locations near Blacksburg, Va. This was believed to be largely due to staphylinid beetles. Parasitism of face flies averaged less than 1%, although up to 30% parasitism by Aphaereta pallipes was observed in late

September and early October. Although the face fly is an introduced pest, it appears that native natural enemies have started to attack the face fly.

5. Stable Flies (Cattle and Horses). Tests were conducted in cooperation with the University of California to determine the effects of three species of fungi on stable flies. The fungi were Aspergillus flavus var. columnaris, Beauveria bassiana and Metarrhizium sp. Seven days after treatment, all the Beauveria treated flies, 31% of the control flies, 59% of the Aspergillus treated flies, and 39% of the Metarrhizium treated flies were dead.

D. Insect Sterility and Other New Approaches to Control

1. Mosquitoes. At Gainesville, Fla., research was continued on the evaluation of the sterility principle for control of mosquitoes. Males of Culex pipiens quinquefasciatus exposed as 1-day-old pupae to 7 to 12 kr of gamma irradiation were not completely sterilized. Untreated females mated to these males showed 87 to >99% sterility. Females irradiated with doses of 2 to 6 kr laid fewer eggs than normal when mated with untreated males. As the dose increased the egg production decreased. Doses of 7 to 9 kr prevented oviposition. Exposure to gamma irradiation reduced the mating competitiveness of the males. Aedes aegypti exposed as third instar larvae failed to pupate after exposure to 4 kr. Adult emergence was good following an exposure to 1 kr, but the sterility was low.

A study was conducted to determine the effect of exposure to the chemosterilant apholate in a sugar-water bait on a natural population of Anopheles quadrimaculatus infesting a cow shed. While 78% of the females that fed on the bait were sterile and 67% of them failed to oviposit, there was no clear indication the baits reduced the number of adult mosquitoes in the treated area.

Studies have been conducted to evaluate dust formulations of chemosterilants against mosquitoes. Technical apholate alone gave almost complete sterility of male Culex pipiens quinquefasciatus. Dusts containing 75% apholate on pyrophyllite caused 98% sterility, but mixtures of 50, 25, or 10% apholate on pyrophyllite produced less than 90% sterility. The sterility obtained with undiluted apholate was retained for at least 11 days, and the sterilized males were about equally competitive with untreated males in mating with untreated females. Males of Anopheles quadrimaculatus were also successfully sterilized with undiluted apholate, and these males competed favorably with untreated males for untreated females under laboratory conditions. However, sterile males of both species that were reared in the laboratory and released into a normally reproducing population in a large outside cage did not compete favorably with normal males.

Dust formulations of tepa and metepa have been evaluated against C. pipiens quinquefasciatus under laboratory conditions. Tepa produced 100% sterility at 0.5% in pyrophyllite, the lowest concentration tested, and metepa gave >99% sterility at the same concentration.

The colony of Aedes aegypti which developed resistance to apholate through laboratory selection is more than 20 times as tolerant to apholate as the regular colony. This strain shows little, if any, cross-resistance to tepa but has a 3- to 4-fold cross resistance to metepa. Resistance to apholate is less in the adults than the larvae.

At Corvallis, Oreg., research was also continued to evaluate the sterility approach for control of mosquitoes. Tests with a new cobalt-60 source confirmed dosages of radiation previously found effective in sterilizing Culex tarsalis, but the data suggest there is sometimes more than one mating by some females. Tepa, hempa, and another chemosterilant were tested as possible sterilants for C. tarsalis larvae. Some sterility was obtained but exposure of the larvae resulted in poor survival of the adult mosquitoes.

Research was conducted under cooperative agreement with the University of Florida to study sterilization of a mosquito by irradiation. Irradiation dosage necessary to produce sterility was determined for adult Culex pipiens quinquefasciatus. A sterilizing dose and a lethal dose was determined for the eggs, but dosages tested with larvae showed lethality without sufficient sterility.

Research has continued under PL-480 at the University of Cairo in Egypt on the control of mosquitoes by chemosterilants. The dosage of chemosterilant needed to produce sterility has been established for Anopheles pharoensis.

2. House Flies. Research was continued at Gainesville, Fla., on the development of sterilization techniques for house fly control. One thousand and four chemicals were screened for chemosterilant activity, and 80 of these caused complete sterility in adults. Twenty-one compounds produced 99 to 100% sterility in males when the insects were offered a choice of treated and untreated food.

In an attempt to develop a simple method of sterilizing house flies with chemosterilants, pieces of polystyrene foam have been immersed in various concentrations of metepa or tepa and used to cover house fly pupae to a depth of 2 3/4 to 7 inches. These treatments have produced high sterility in the insects that emerged through them. Applications of 5 and 7.5% metepa produced 97 to 100% sterility while 5% tepa caused 100% sterility.

Male house flies have been successfully sterilized by confining them in cages with females that were carrying pads impregnated with Olin 53330 on their abdomen or that had been treated directly on the dorsum of the abdomen with Olin 53330, metepa, or tepa. The males were almost completely sterile for 15 days. When the chemicals were applied directly to the abdomen, males exposed to virgin females treated with Olin 53330 or tepa became completely sterile for at least 15 days.

Triphenyltin acetate has been found an effective chemosterilant in laboratory tests when offered to mixed sexes of house flies at concentrations of

0.01%-0.025% in a dry sugar bait if the insects had a choice between treated and untreated food. When only treated food was furnished the flies usually were killed before they could lay.

At Corvallis, Oreg., research was continued on methods of sterilizing the little house fly. The median sterilizing dose is about 600 r for females and 400 r for males when irradiated as pupae. When irradiated in the adult stage, 3 to 4 days old, greater doses were required; 900 r for females and 600 r for males.

At Beltsville, Md., investigations of physical methods for fly control were continued in cooperation with the Agricultural Engineering and Animal Husbandry Research Divisions. Mechanical devices, including electrocutor grids, the grids plus lights, and lights plus toxicant (attractant-toxicant devices) all proved ineffective for control of house flies outdoors in cattle pens. Unlighted devices were no less effective than lighted ones, indicating random flights to all units and not attraction. Attractant-toxicant devices of three types tested inside barns killed slightly larger numbers of flies.

Research has continued under PL-480 at the University of Cairo, Cairo, Egypt on the control of house flies by chemosterilants. The dosage of chemosterilant needed to produce sterility has been established for Musca domestica vicina.

3. False Stable Fly (Cattle).

In Oregon, studies on the effects of gamma radiation on false stable fly, Muscina stabulans were initiated. Late stage pupae were exposed to 1750 r and 5250 r. Females given the shorter exposure were incapable of ovipositing. The sterilizing exposure for males is near 5250; less than 1% of the eggs from treated males-normal females crosses hatched.

4. Screw-worm (All livestock except poultry)

Of 359 compounds screened as chemosterilants in Mission, Texas, 42 caused sterility in one or both sexes of screw-worm flies when fed to adults. Evaluation of chemosterilants passing screening tests showed that ENT-50441 sterilized males and females when fed orally or applied topically.

A homologous series of compounds of formula $[\text{CH}_2\text{CH}_2\text{NCONH}]_2(\text{CH}_2)_n$, when n is 4 to 10, was tested topically and orally against adult screw-worm flies. Lengthening the aliphatic chain tended to decrease toxicity; lengthening the aliphatic chain beyond $n = 7$ tended to decrease chemosterilant action.

Males sterilized by tarsal contact with a residual film of ENT-50838 on glass (20 mg/0.09 m²) or by intrathoracic inoculation (0.5 and 1%) were less competitive sexually than fertile males. Male screw-worm flies sterilized topically with 5, 10, and 15% ENT-50838 were more competitive sexually

than fertile males by a factor that increased as the concentration increased.

ENT-50838 sterilized males (topical) first mated when 5 days old and others when 12 days old and thrice more at 48-hr intervals were completely sterile at all matings. Age and repeated matings adversely affected the fertility of control males.

Screw-worm flies were treated topically with graded doses (0.1 to 10%) of ENT-50838. The rate of induced dominant lethal mutations was low at 0.1% increased rapidly to 0.5%, and leveled off at 1% in both sexes.

Screw-worm flies of each sex were treated topically with ENT-50838 and maintained at 26 and 37° C. Elevated temperature alone exerted an adverse effect on egg hatchability. However, elevated temperature appeared to have no further adverse effect on the fertility of flies also treated with chemosterilant.

The competitive mating ability of young and old chemosterilized screw-worm males was compared. Old males (15 days) treated with ENT-50781 or 50838 were less competitive than young males (5 days) similarly treated. Although young males treated with ENT-50781 were at least as competitive as untreated males, old males were slightly less competitive. With ENT-50838, young and old males surpassed untreated males in competitive mating ability. Thus, there was an unfavorable effect owing to age on the mating ability of chemosterilant-treated males. Whereas this factor influenced their competitive mating ability adversely with ENT-50781, it did not with ENT-50838.

Chemosterilant-treated (ENT-50781, 50838) flies contaminated their environment from which other flies acquired chemosterilant and suffered adverse effects of fertility slightly with short exposures (24 hr) and more severely with long exposures (7 days).

Screw-worm flies were treated orally with different concentrations of sugar syrup containing 1% ENT-50781. Egg hatchability increased progressively as the concentration of sugar syrup used as the vehicle for 1% chemosterilant fed to both sexes decreased from saturation to 0.1% of saturation. When the length of time males fed on 1% chemosterilant was increased from 1 to 24 hr, egg hatchability decreased more rapidly if saturated sugar syrup was used instead of 0.1% of saturated sugar syrup.

The effect of ENT-25296 on sperm stored in the spermathecae was determined by treating males topically with a substerilizing dose and mating the males with females that were stimulated to oviposit 3 times at 3-day intervals. Sterility was increased in sperm that was stored by females for 3 and 6 days prior to fertilization of the eggs.

Mating tests with ENT-50990 treated males, when combined at different ratios with fertile males, were less competitive.

The sexual vigor of males treated orally with 0.1% ENT-51254 or 51256 in sugar syrup or topically with 10% ENT-51256 in water was evaluated. Orally administered chemosterilants did not affect male sexual vigor adversely, but this was not the case with topically applied ENT-51256. Males treated orally with ENT-51254 and 51256 showed that ENT-51254 sterilized males were about twice as competitive sexually, but ENT-51256 sterilized males were about a third less competitive.

5. Horn Flies (Cattle). Studies in Texas indicate that both horn fly pupae and newly emerged adults of the Kerrville laboratory horn fly colony could be sterilized with 3000 r of gamma rays but these flies were not fully competitive sexually. As part of the studies, a preliminary field release of sterile horn flies was made on a semi-isolated herd of cattle at Camp Stanely, Texas. Although cross-fertilization occurred, some viable eggs were obtained during the 6-week study. One phase of the work utilized alternately a non-residual insecticide and sterile-fly release. This combination appeared to be more promising than sterile-fly releases alone.

6. Lice (Goat). Tests in Texas on the effects of Co-60 irradiation on the Angora goat biting louse showed some female lice can withstand a dosage as high as 8600 r but above 4300 r above-normal mortality occurs. Preliminary evidence indicates that 3000-4000 r reduces the viability of eggs laid by irradiated females but does not completely eliminate hatching.

7. Ticks (Cattle and Dogs). In Texas, engorged nymphs of the Gulf Coast tick, Amblyomma maculatum, were exposed to three levels of radiation (Co-60) at three intervals during the molting period. A level of 860 r had no effect on molting; levels of 2150 and 4300 prevented molting of nymphs exposed at 1 week after engorging. A few adults from nymphs exposed to 4300 r engorged. Females from nymphs treated with 2150 and 860 r did not produce viable eggs when mated to untreated males. The radiation effect varied according to the sex of the treated tick as males from nymphs treated with 2150 and 860 r produced some viable eggs when mated to normal females.

At Kerrville, Texas, engorged nymphal Rhipicephalus sanguineus, brown dog ticks, were exposed to gamma radiation of 500, 1000, 2500, and 5000 r at 1, 5, 11, and 15 days postengorgement. Nymphs exposed to 2500 and 5000 r at 1 and 5 days postengorgement did not molt to adults. Adults from irradiated nymphs were mated with normal adults, and effects on engorging, egg laying, and hatch of eggs were recorded. A dosage of 500 r had no effect. At 1000 r there was some reduction in size of females, size of egg masses, and percent hatch. At 2500 r, treated females did not lay eggs, but normal females mated to treated males laid a few eggs that hatched. At 5000 r, treated females did not engorge; a few untreated females mated to treated males engorged and laid some eggs that hatched.

8. Tsetse Flies. Under a PASA agreement with AID, research was continued in Salisbury, Rhodesia in cooperation with the Agricultural Research Council of Central Africa on the feasibility of the sterile male technique for the

control of tsetse flies. Seasonal influences were detected in chemosterilization trials. Overall G. morsitans survival was reduced by wind tunnel and contact treatments with tepa and metepa in both the winter and summer seasons; however the major factor influencing survival was season. Competitiveness, insemination, and sterility were not affected by season. Chemosterilization of 1-day old G. morsitans males with tepa in the wind tunnel and by contact exposure resulted in complete sterility and competitiveness. Competitiveness was less than expected in similar trials with metepa, although complete sterility was obtained.

Wind tunnel application of 0.25 ml of 5% tepa failed to sterilize G. pallidipes completely, but 0.5 ml was effective and provided permanent sterility. Exposure of G. pallidipes males to gamma-irradiation resulted in increasing sterility and decreasing survival as the dosage was increased from 4,000 to 16,000 r and as pupal age at the time of treatment was decreased, but complete sterility was rarely achieved. G. pallidipes females, with one exception, were completely sterilized with 4,000 to 8,000 r but survivals were not affected by the treatment. Irradiation of adult males with 8,000 to 16,000 r was not as effective as pupal treatment and resulted in decreased survival.

Irradiation of G. morsitans males when 1 or 6 days old with 8,000 to 15,000 r of gamma radiation from Co-60 resulted in 93 to 97% sterility. Females were completely sterilized with 2,000 to 4,000 r. Both sexes appeared to survive better than the controls. Fractionated dosages of 2,000 X 4, 4,000 X 2, 4,000 X 3 and 5,000 X 3 given one day apart to pupate did not reduce male fertility quite so much as continuous exposure to 8,000, 12,000 and 15,000 r, respectively. Male longevity was better than with continuous exposures, but below the control longevity, and was similar to that expected from a single exposure to 4,000 r.

An interesting finding was that sterile G. morsitans males can act as vectors of trypanosomiasis when the sterilization treatment precedes the infection in the fly; the data suggest that transmission is reduced when the treatment occurs after the fly is infected.

Attractant investigations in the laboratory have not indicated that G. morsitans females produce a chemical sex attractant, but preliminary bioassays resulted in positive male response to lipid fractions from virgin, mature females. Males appeared to respond and attempt mating only after visual attraction to active females, but generally lost interest rapidly if they failed to copulate almost immediately. Painting the eyes of the male reduced mating, but not feeding, in small cages. Removing the antennae of either sex, or the halteres and wings of females, did not affect mating under laboratory conditions.

None of the three large cages at the Chirundu station have provided adequate conditions for prolonged G. morsitans survival. Oxen, warthogs and bushpigs

were used as host animals. Extensive modifications to alter the light patterns within one cage have resulted in improved feeding by the flies, but not survival. In an intermediate size cage, which consists primarily of large cement pipes, survival has been extended to 22 days but 50% of the flies died in the first 5 days. Poor survival also occurred in the vertical cage which encloses two trees. Fly behavior and movement was observed in this cage with the aid of radioactive Tantalum.

Small cages containing G. morsitans were placed inside the large field cages during the trials. Survival was much better within the small cages than in the large volume of the big cages. Small cages of flies in the controlled environment room and in the varying climate of the wicker cage have demonstrated good survival and reproduction rates, although flies released in the large volume of these two cages do not survive well.

Attempts to concentrate a breeding focus of Glossina have not been successful. After two separate one-year trials, involving the positioning of cattle in favored tsetse areas, no permanent fly buildup has resulted.

Population surveys showed that G. morsitans density on Long Island, the site selected for a small field release experiment, remained relatively stable from November to May, increased rapidly through August-September, and then to fall sharply to return to the November levels. Population densities were estimated at 3700 to 5300 per square mile depending on the season. Separate field trials demonstrated that marked G. morsitans males dispersed sufficiently to satisfy the assumptions of the statistical model used to estimate the population on Long Island.

9. Mites (Poultry). Research on the evaluation of chemosterilants as a means of control for the northern fowl mite was initiated under grant support at the University of Mississippi. The internal morphology of the reproductive system was studied. Isolation apparatus to confine the test birds and mites were constructed so that at least two compounds can be tested simultaneously. Three candidate chemosterilants are now being evaluated.

E. Insecticide Residue Determinations

1. Residue Studies. In Texas, studies were conducted to determine whether certain insecticides applied to dairy cows would contaminate the milk. Two dairy cows were treated with a 2% or a 5% malathion solution in xylene. The insecticide was applied with a single nozzle, low-volume, automatic sprayer adjusted to deliver 1 ml of solution in a mist across the backs of the animals, covering an area about 30 cm wide extending from the withers to the loin. The animals were treated twice daily after milking, for a period of 21 days. Samples of milk were taken before treatment on the first day of the test and at intervals up until 21 days after the treatment started. Analysis by a method sensitive to 0.001 ppm of malathion revealed no residue of this insecticide in the milk.

In Texas, two dairy cows were sprayed twice daily for 28 days with 1 ml of solution of ronnel in xylene. A 5% solution was applied to one cow and a 10% solution to the other. Residues of ronnel were detected in the milk from both cows one day after spraying began and increased to a maxima of 0.14 and 0.35 ppm, respectively.

In Texas, two dairy cows were exposed to a back rubber treated with the recommended amount of 2% ronnel in oil (1/2 gal/10 ft) twice daily for 14 days. The back rubber was then retreated and used for another 14 days. Milk samples were taken after 1, 3, 5, 7, 10, and 14 days exposure. Two other cows were exposed to a back rubber treated with twice the recommended amount of 2% ronnel solution in oil twice daily for 14 days. Milk samples were taken at the same intervals as before. Ronnel was not detected in any of the 20 milk samples taken from the cows using the back rubbers treated with the recommended amount of ronnel. In the case of the cows exposed to the rubbers treated with twice the recommended amount of ronnel, their milk contained 0.002 and 0.007 ppm of ronnel after 1 day's exposure and 0.003 and 0.002 ppm after 3 days. No residues were detected during the rest of the period of study.

In Maryland, no residues of dimethoate or its oxygen analog were found in the milk of cows given oral administrations daily for 14 days of 0.50 mg/kg of dimethoate and 0.05 mg/kg of its oxygen analog in capsules. When the doses were doubled, oxygen analog ranging from 0.001 to 0.125 ppm was found in the milk but no dimethoate was detected. Milk samples were taken throughout the entire time.

In Georgia a gas chromatographic procedure utilizing a flame photometric detector was developed for the determination of residues of coumaphos and its oxygen analog in milk and feces. This method was used in a study of the residues resulting when coumaphos (0 to 48 ppm in air-dried feed) was fed to dairy cows to study its activity against house fly larvae emerging in the cows' feces. Neither coumaphos nor its oxygen analog was found in the milk of the cows. Coumaphos appeared in the feces.

A gas chromatographic procedure was also developed in Georgia for determination of residues of Shell SD-8447 (2-chloro-1-(2,4,5-trichlorophenyl)vinyl dimethyl phosphate) in milk and feces from dairy cows that had been fed the insecticide in a study of its activity against house fly larvae emerging in the cows' feces. Milk from cows fed amounts of SD-8447 ranging from 0 to 844 mgg contained no detectable residues of SD-8447 or its hydrolysis product. In the feces, from <0.013 to 0.498 ppm (dry basis) of SD-8447 was found, but its hydrolysis product was not detected.

Further residue studies in Texas with Shell SD-8447 were conducted. Emulsion sprays of Shell SD-8447 at 0.125, 0.25, and 0.5% concentration were applied to cattle one time by normal spraying procedures. Analyses were made of omental, renal, and subcutaneous fat, and also of muscle, heart, liver,

kidney, spleen, and brain when residues of 0.002 ppm or more of SD-8447 were found in the fat. The maximum residue found was 0.108 ppm in omental fat of a calf that received an 0.5% spray and was slaughtered 1 week after spraying. Two groups of cattle were then sprayed to saturation with an emulsion containing 0.25% SD-8447. All tissues were analyzed from one group at 1 and 3 weeks after treatment. For the other group only the fat samples were analyzed at 1, 2, and 3 weeks after treatment. The only residues found were in the fat and these were no longer detectable (≤ 0.002 ppm) by 3 weeks after treatment.

Analyses were made for residues of the oxygen analog of Dursban in the body tissues of cattle after three dippings at 2-week intervals in 0.05% Dursban emulsion. Seven days after the treatment 0.02 ppm of the oxygen analog was found in the omental fat and 0.03 in the renal fat. No measurable residues were found in the muscle, spleen, or brain and none were detected in the omental fat and renal fat 10 weeks after treatment.

In Texas a method was worked out for the determination of Stauffer R-3828 (S-(p-chloro- α -phenylbenzyl) 0,0-diethyl phosphorodithioate and its oxygen analog in the body tissues of cattle. Results obtained thus far show that a calf which received 5 mg/kg of R-3828 daily for 14 days had 40.4 ppm of R-3828 and 0.73 ppm of the oxygen analog in the omental fat, while another calf receiving 10 mg/kg daily had 133.0 ppm of R-3828 and 2.50 ppm of the oxygen analog. In a metabolic study of the compound, a single dose of 100 mg/kg of C¹⁴-labeled R-3828 was given by capsule to a calf. Fat samples taken from this calf contained 118.0 ppm of R-3828 and 0.27 ppm of its oxygen analog 13 days after treatment and 2.0 ppm of R-3828 and less than 0.005 ppm of the oxygen analog 63 days after treatment. The compound produced the highest residues in the fat of cattle of any organic phosphorus insecticide thus far studied. An 8 week feeding test with this insecticide was completed.

Animals receiving 5 mg/kg of R-3828 daily had a residue of 81 ppm in the fat at the end of the 8 week feeding period; this residue decreased to 10.4 ppm 42 days after feeding ceased. Animals receiving 10 mg/kg daily had 170 ppm in the fat at the end of the feeding and 16.5 ppm 42 days after feeding ceased. The fat of the animals receiving the lower dosage contained 2.10 ppm of the oxygen analog of R-3828 at the end of the feeding period. The fat of those receiving the higher dosage contained 2.0 ppm.

In Maryland, cuts of pork and pork products from hogs fed diets containing heptachlor (2.8 ppm) and DDT (34 ppm) were analyzed for pesticide residues. In the cooked meats heptachlor epoxide residues were found ranging from 0.6 to 0.8 ppm in lean meat, 0.8 to 3.4 ppm in fat and drippings, 0.1 to 0.2 ppm in ham, and 1.3 to 2.4 ppm in bacon and bacon drippings. The combined residues of DDT and its analogs ranged from 2.2 to 12.8 ppm in lean meat, 4.8 to 19.7 ppm in fat, 1.5 to 3.0 ppm in hams, and 5.6 to 37.2 ppm in bacon and drippings.

In Maryland, beef calves were fed a mixture of dimethoate (0.30 mg/kg body weight) and its oxygen analog (0.03 mg/kg) daily for 14 days. Analysis showed no residues of dimethoate or its oxygen analog in selected organs, blood, or muscles from the calves.

In Washington, residue studies in cattle from the Burns Tassock Moth Project were continued. Adipose tissue of cattle from areas treated with DDT (0.84 kg/hectare) applied in the spring of 1965 was analyzed for DDT and its metabolites. Samples were taken in the fall of 1965 and the spring and fall of 1966. Based on 100% extractable lipids, the ranges and averages of combined DDT and its metabolites were: for the fall of 1965, 6.3 to 16 ppm (average 12 ppm, 9 cattle); spring of 1966, 0.5 to 14.6 ppm (average 5.5 ppm, 10 cattle); the fall of 1966, 0.1 to 4.5 ppm (average 1.1 ppm, 10 cattle).

In Washington, DDT residue studies in wild game were made. In 1964, 500,000 acres of the Salmon National Forest were sprayed with DDT for control of the spruce budworm. Samples of adipose tissue were collected during the 1965 hunting season from 27 deer and 17 elk and were analyzed for combined DDT isomers and metabolites. Based on 100% lipid content, the residue found in the deer ranged from 0.035 to 5.11 ppm (average 1.92 ppm) and in the elk from 0.27 to 3.78 ppm (average 3.07 ppm). This project was in cooperation with the U. S. Forest Service and the Idaho State Fish and Game Department.

In the spring of 1965 DDT was applied at the rate of 0.84 kg per hectare in forests in Oregon and for the control of the tussock moth. Samples of adipose tissue were collected from 17 deer and 1 elk (killed between July 27 and August 31, 1965) and were analyzed for DDT and its metabolites. On the basis of 100% extractable lipids, the residues found in the deer ranged from 0.07 to 31 ppm (average 4.60 ppm). Two control deer killed outside the treated area had residues of 0.15 and 0.13 ppm (average 0.14). The elk adipose tissue contained 1.83 ppm. This project also was in cooperation with the U. S. Forest Service.

In Washington, the persistence of the insect chemosterilant, tepa, in bird mash feed was determined. In 2 samples of the mash the initial levels of tepa were 9.2 and 16.8 ppm, whereas theoretically they should have been 25 and 50 ppm. (These samples were fortified with tepa at Davis, California, and shipped frozen to Yakima. Control samples fortified at Yakima contained the theoretical amount.) Similarly treated samples that had been held in bird cages for 7 days were found to have 0.00 and 0.24 ppm of tepa. This work was in cooperation with the U. S. Fish and Wildlife Service.

F. Attractants

1. Mosquitoes. At Gainesville, Fla., the olfactometer system was adapted for screening of chemicals as mosquito attractants. One hundred and forty-five chemicals were screened. Of these 9 showed some promise as possible attractants. Four of the 9 were propanediols. The procedure was revised to include a second technique with each compound. A flow of carbon dioxide (5-10 ml/min) was introduced with the candidate chemical to determine

whether the addition of the gas would increase the attractancy. Nineteen of 64 chemicals showed some attraction. Five percent or more female A. aegypti were attracted by 4 of the compounds with or without carbon dioxide, by 3 without carbon dioxide and by 12 with carbon dioxide.

Studies at Corvallis, Oreg., were also continued on the attractive principle in log pond waters. Chloroform extracts of both log pond water and cold-trapped odors from these waters were attractive to ovipositing Culex pipiens pipiens. Even the presence of log pond odors caused more oviposition on distilled water than occurred in the absence of the odors, but more egg rafts were deposited by C. p. quinquefasciatus females when they were able to contact log pond waters. In initial tests, chromatographed fractions of log pond water extracts included fractions highly attractive to ovipositing pipiens, quinquefasciatus, and C. tarsalis, and one fraction repellent for the three species. However, in further studies with waters from six different log ponds, the repellent fraction was not found with chromatography. There has been some evidence that the presence of cedar was detrimental to mosquito breeding, but no clear-cut evidence of toxicity was found with extracts of cedar roots, heartwood, or sapwood, and waters holding cedar logs received 12 times as many egg rafts of C. p. pipiens as did the distilled water controls. Water from ponds holding Douglas fir logs received 9 times as many egg rafts as the controls. Chloroform extracts of Douglas fir phloem showed little promise, but extracts of bark produced fractions with attractiveness near that of log pond water extracts. The chromatographed R_f values of extracts of fir bark and log pond waters were comparable, therefore further isolation of the fir bark extracts was made. The acid derivatives were more attractive than basic derivatives, but the attractancy was apparently related to a combination of materials and not necessarily to a single extractable.

At Corvallis, Oreg., research continued with what are believed to be sex pheromones of mosquitoes. Virgin female Culex pipiens quinquefasciatus, C. p. pipiens, and C. tarsalis respond to pheromones of the males of their respective species or subspecies, and also to those of the males or opposite subspecies or the other species. To some degree, males are also attracted. Female quinquefasciatus and pipiens given a 6-day opportunity to mate also showed attraction to males of the three species in the olfactometer.

2. House flies. Research was continued at Corvallis, Oreg., on the sex pheromone reported earlier in the house fly. Response of flies was found to be somewhat variable, but the response occurred with wild flies, as well as laboratory strains, and colonization of a wild strain for 12 generations produced no loss or gain of the pheromone. In other tests with individual flies it was noted that apparently the threshold of pheromone needed to stimulate mating varied with individual flies. A strain of blind flies still responded to the pheromone, although with normal flies a visual stimulus (such as a dead fly or object the size and rough shape of a fly) usually enhances the response. Efforts to purify, characterize, and identify

the pheromone are continuing as a joint project with chemists at Beltsville, Md. Over 250 independent materials, purified fractions, and extracts have been tested, but the pheromone has not yet been isolated. The pheromone is apparently a recognition mechanism, that identifies the opposite sex of its own species for the male house flies, which will initiate strike against any fly their size, including other males, but remain to copulate only with female house flies which, of course, have the pheromone.

3. Horn flies. Research was initiated under grant support at the New Mexico State University, Las Cruces, on the response of the horn fly to extracts of animal tissues and to putrefaction products. A laboratory colony was established, two types of olfactometers were built and are being evaluated. Preliminary tests indicate that water and petroleum ether extracts of bovine hide and hair or water extracts of skatole and indole were not attractive to newly emerged flies.

4. Screw-worm (All livestock except poultry). In Texas 231 chemicals were screened as screw-worm attractants. None were found to be as effective as the standard liver bait.

Differences have been found in the response of unmated females of 2 laboratory strains of screw-worm flies (from Florida and Mexico respectively) to a male pheromone from each of these strains. The Florida strain females, under colonization for a period of 10 years, responded to the male pheromone of both strains with characteristic aggressive behavior. Females of the Mexican strain (colonized about 2 1/2 years) did not respond to the pheromone from either strain. It is postulated that the difference in response by females of both strains may be explained, at least in part, by selection brought on by some of the techniques used in mass production over extended periods of colonization.

Limited tests with odors collected from screw-worm infested sheep and extracted with ether have indicated that the method of presentation affects the overall response by male and female screw-worm flies. In laboratory tests fly catches on the wheel-type olfactometer were found to be predominately male (86%), while flies captured in wound odor baited traps attached to a sheep were found to be only 4% male. These tests were run simultaneously. Fly catches in field tests made with irradiated flies and the wound odor-trap attached to sheep have been 100% female. The fact that controls (sheep + odorless trap) captured a few female screw-worm flies (range 0 to 5) is interesting and suggests that an "animal factor" is involved in female screw-worm response.

G. Insect Vectors of Animal Diseases

1. Anaplasmosis (Cattle). In 1966 studies in Mississippi were designed to evaluate the relative importance of Culicidae and Tabanidae as vectors of bovine anaplasmosis. Three splenectomized anaplasmosis negative steers and one anaplasmosis carrier steer were exposed continuously outdoors to attack

by horse flies and mosquitoes for a six-week period. A similar group was exposed in a screened building which excluded the horse flies. Two of the three susceptible animals in the outdoor exposure developed anaplasmosis. None of the animals in the screened group developed anaplasmosis. Groups of susceptible animals exposed for two-week periods during the six-week study indicated that transmission of the disease occurred primarily during the second two weeks of the test.

Collections from bait animals, light traps, and animal-baited insect traps showed that the main mosquito species involved were Psorophora confinnis and Anopheles quadrimaculatus; the main tabanid species were Tabanus subsimilis, T. lineola, and T. fuscicostatus. The periods of peak populations of the Culicidae occurred during the last two weeks of the test period, and of the Tabanidae during the first two weeks of the test period.

The data accumulated from the 1965 and 1966 studies indicate that mosquitoes probably do not and that horse flies do play a major role in the transmission of anaplasmosis.

Observations made on bait animals during the study in 1966 indicate Hippelates or eye gnats need to be investigated for their role in anaplasmosis transmission. These insects are associated with horse flies at the time horse flies are feeding on the animal. The Hippelates are apparently attracted to the blood from the wounds made by the horse flies and feed readily on this blood. Hippelates were present on the animals in the pasture but were not on the animals within the screened building. The main peak of activity for these flies occurred during the period when transmission was believed to have occurred in the field.

Cooperative studies with the Animal Disease and Parasite Research Division continued at Beltsville, Maryland, on the transmission of bovine anaplasmosis, but at a much reduced level. Attempts are still being made to establish naturally infected colonies of ticks from anaplasmosis enzootic areas. One transmission trial was conducted with the tropical horse tick, Dermacentor nitens. The ticks were allowed to feed on a calf which was in the acute stages of Anaplasma marginale infection and the F₁ progeny of these ticks were tested on a splenectomized calf. Anaplasmosis was not transmitted. Further transmission trials with this species are planned.

2. Equine piroplasmosis. Cooperative studies with the Animal Disease and Parasite Research Division were continued at Beltsville. A colony of tropical horse ticks, Dermacentor nitens, infected with Babesia caballi has been established. This colony transmitted the disease to susceptible horses when tested at each of 3 successive generations. Babesia caballi appears to be transmitted by D. nitens early in the nymphal feeding period. Test horses developed patent parasitemias 3 to 6 days after the larval-nymphal molt. The parasitemias persisted at varying levels in the test horses throughout the period when the adult ticks were feeding thus insuring development of B. caballi in the replete females and infection of the following generation of ticks.

Studies of the life cycle of B. caballi in D. nitens indicate that development may begin 48 to 72 hours after the parasites are ingested. Babesia caballi invades the gut epithelial cells of the tick and undergoes multiple fission releasing motile vermicular shaped parasites which invade developing ova and other tissues of the tick. Parasite development appears to be quite slow in the eggs, however late in the incubation period, or early in the larval feeding period, the multiple fission cycle is repeated releasing vermicular forms, some of which invade the salivary glands of the larvae or nymphs. Multiple fission occurs again in the salivary glands resulting in large numbers of small (1.5 to 3.0 μ) oval or piriform parasites which are infective to horses. Additional studies on the precise mode of development, predilection of tissue, and longevity of B. caballi in D. nitens are being continued.

3. Bluetongue (Sheep, Cattle, Goats, and Ruminant Wildlife). Studies have continued on the biology of insect vectors of bluetongue disease of sheep and cattle and the role of insects in the transmission of the disease in cooperation with the Animal Disease and Parasite Research Division at Denver, Colo. It was reported previously that flies (Culicoides variipennis) fed on vaccinated sheep (egg-attenuated modified live vaccine - Blucine) were able to pick up the virus. The virus multiplied in the insect and a virulent form of the disease was passed to susceptible sheep by the bite of these flies. This research indicates that vaccination with modified live virus vaccines, at least for bluetongue, should be done only in areas where the disease is endemic, since its use in other areas may only serve to spread the disease among livestock or setup a foci of infection in wildlife. It was also found that the bite of a single infected fly was sufficient to transmit the disease from sheep to sheep. About 6% of flies fed on vaccinated animals became infected compared to 10% of those fed on animals inoculated with virulent virus. In these tests, the serial transmission of the vaccine virus by fly bite was shown through a series of several sheep.

The occurrence of several strains of bluetongue virus in the United States has been shown by the Animal Disease and Parasite Research Division. Sentinel sheep established in the field at an epizootic of bluetongue in cattle in Montana apparently picked up some immunity to one strain of virus (BT OX 254). This immunity did not protect 2 of the 3 animals against challenge with the standard BT 8 virus. Research is continuing on the cytological and physiological changes that occur in the structure of the salivary gland of C. variipennis almost immediately after flies are given a blood meal.

The methods used to maintain the colony of C. variipennis have been drastically changed. Primarily the larval medium now consists of a bacterial broth nourished with commercially available products, rather than relying on cow manure as the primary ingredient.

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LIVESTOCK ENGINEERING
Agricultural Engineering Research Division, ARS

Problem: Modern production trends are demanding more basic knowledge about the effects of environment on the health, growth, production and fertility of livestock; about structures and related equipment for maintaining desirable environments; and about methods, structures and equipment for more efficient handling and feeding. The continuing threat of nuclear warfare demands consideration of types of buildings that will provide protection from fallout for livestock and their feeds and provide facilities for operation during periods of emergency.

Closely associated with the environment are flies and other insects. To minimize the use of chemicals for insect control there is need for developing electrical or physical means of controlling insects that affect livestock production. How to adapt existing buildings and other facilities for more efficient production, as herds and flocks are increased in size, or as farms are consolidated, is a major problem area. The flow of materials pertaining to livestock production such as feed, bedding, and wastes with the use of automated and power equipment make the farmstead arrangement an important factor affecting the efficiency of operation. Adaptations and improvements are needed to keep design of such equipment as feedbunks, self-feeding silos, and feeding floors abreast of current production practices. Improved methods of detection and control of Salmonella are needed.

Automatic running water systems, more water-using equipment, new uses for water, higher standards of sanitation, and other factors are continually increasing the demand for water on the farmstead -- both in quantity and quality.

Disposal of organic wastes -- principally manures and sewage -- is becoming more and more of a problem on the modern farmstead. The cattle, hogs, horses, sheep, and poultry on farms and in feedlots in the U.S. produce more than 2 billion tons of manure annually. The problem is particularly acute with respect to confinement-type livestock operations on the fringes of metropolitan areas where the total amount of manure is concentrated in the confinement area, odors and dusts are generated and land areas for disposal are remote. Under these conditions, it is difficult to avoid creating a sanitation hazard or a public nuisance. Economical sanitary means of disposition need to be developed. Among means that need to be investigated are lagoons, irrigation systems, subsurface absorption systems and reclamation. Development of improved methods for disposing of sewage in those rural areas where conditions are adverse to the conventional septic tank system (high ground water, shallow rock, nonabsorptive soils, restricted areas) is needed.

The arrangement plan of the farmstead has an important bearing on its efficiency, appearance, and liveability. For example, convenient locations for feed and bedding storage ease the distribution chore. A 40-cow dairy herd will use approximately 240 tons of silage, 60 tons of grain, 40 tons of hay, and 20 tons of bedding annually. Research is needed to evaluate the various planning factors in the light of current equipment and practices and to develop planning principles and guidance materials for the benefit of farmers, particularly those contemplating changes.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers, architects, electrical engineers, and physicists engaged in basic and applied research in cooperation with prerepresentatives of other research disciplines. Much of the work is conducted cooperatively with State Agricultural Experiment Stations and industry. The program is conducted and reported under the following categories with the Federal research effort in terms of scientist man-years shown in parentheses at the end of each statement.

A. Dairy Cattle Engineering. Dairy cattle environmental and bioengineering studies are conducted in a climatic laboratory at Columbus, Missouri, in cooperation with the Dairy Husbandry and Agricultural Engineering Departments of the Missouri station. AH, ARS, serves in an advisory capacity. The influence of building arrangement, equipment, and chore routines on the amount and drudgery of dairy chores and means of improving these factors are studied in cooperation with the California Agricultural Experiment Station. Typical plans for dairy structures are developed at Beltsville, Maryland. (1.1)

B. Beef Cattle Engineering. Beef cattle structures and equipment research for hot, dry climates is conducted in cooperation with the California Agricultural Experiment Station at the Imperial Valley Field Station, El Centro. Typical plans for beef structures are developed at Beltsville, Maryland. (1.2)

C. Swine Engineering. Swine structures and equipment research for hot, dry climates is in cooperation with the California Agricultural Experiment Station at Davis and for hot, humid regions at Tifton, Georgia, in cooperation with the Georgia Coastal Plain Experiment Station and AH, ARS, on an "occasional visit" basis (currently inactive). Typical plans for swine structures are developed at Beltsville, Maryland. (1.4)

D. Poultry Engineering. Poultry house environmental design criteria are investigated in controlled temperature laboratory studies at Beltsville, Maryland, in cooperation with AH, ARS, and the basic laboratory data are applied to experimental poultry houses of the NE-8 Regional Project for evaluation. Limited field studies on relation of housing structures to poultry disease are conducted in Mississippi in cooperation with the State Agricultural Experiment Station and AH, ARS. Environmental influences on health and housing requirements are investigated in new laboratories at Athens, Georgia, and State College, Mississippi, in cooperation with AH and ADP, ARS, and the respective State Agricultural Experiment Stations. At St. Paul, Minnesota, a study of the role of environment in the prevention and control of chronic respiratory disease in turkeys is underway in cooperation with the Minnesota Agricultural Experiment Station. Typical plans for poultry structures are developed at Beltsville, Maryland. (3.6)

E. Extracorporeal Irradiation of Farm Animal Blood. Research to develop new techniques and equipment for studying blood diseases of farm animals at Beltsville, Maryland, and Ames, Iowa, in cooperation with ADP and Atomic Energy Commission. (0.1)

F. Radiosity Studies. Studies of radiosity (total radiation) of the sky, ground, and surroundings are conducted at Davis and elsewhere in California and at Columbia, Missouri, in cooperation with the respective agricultural experiment stations. (Less than 0.1 SMY)

G. Reducing Pesticide Residues in Animal Products. Reduction of pesticide residues in animal products, with beef cattle receiving major attention, is studied at Kerrville and College Station, Texas, in cooperation with ENT and ADP, ARS, and the Texas Agricultural Experiment Station. A program is being developed for the engineering aspects of research in the planned Southwestern Veterinary Toxicology and Livestock Insects Research Laboratory at College Station, Texas. (1.5)

H. Water Supply and Wastes Disposal for the farmstead are studied at Beltsville, Maryland, and College Park, Maryland, in cooperation with the Maryland Agricultural Experiment Station and Watkinsville, Georgia. Liaison is maintained with SWC (ARS), the Public Health Service, the Water Systems Council, the American Society of Agricultural Engineers, and other organizations concerned with rural sanitation. (2.0)

I. Farmstead Planning studies are made at Beltsville, Maryland, at St. Paul, Minnesota, in cooperation with the Minnesota Agricultural Experiment Station, and at Davis, California, in cooperation with the California Agricultural Experiment Station. (1.1)

J. Fly Control in dairy operations is studied at Beltsville, Md. (1.3)

K. Equipment for Livestock and Poultry Feeding is under development at the Washington and Illinois State Experiment Stations. Work on performance characteristics of upright-silo unloaders and special duty motors is in cooperation with the Minnesota State Experiment Station. (2.0)

L. Electric and Solar Equipment for Environmental Control. Research on equipment for basic and applied studies involving light and thermal environment for poultry is underway at Beltsville in cooperation with the Poultry Branch, ARS. The influence of electric equipment and environment on health and disease is being studied in USDA laboratories at Athens, Georgia, and State College, Mississippi. (3.3)

Studies on the performance of milk handling equipment are underway at Beltsville in cooperation with the Animal Husbandry Research Division and the Eastern Utilization Laboratory. (1.0)

PROGRAM OF STATE EXPERIMENT STATIONS

There is an extensive program of both basic and applied research underway at the State Agricultural Experiment Stations in an effort to provide the answers to the continuing series of questions being raised by livestock producers. Demands are being made for more information on the effects of environment on the physical well-being of all classes of livestock, and the way such optimum environments can be economically achieved; on new approaches to meet the growing labor shortage; on methods to adapt existing structures and equipment for greater economy of production; and on structures and related equipment for improved efficiency of feeding and materials handling operations.

Studies are being made on the effect of environment on the health, growth, production and fertility of dairy cattle, beef cattle, poultry and swine. Equipment and systems for efficiently transporting feedstuff into and out of storages and automatically mixing and feeding complete rations are being developed.

Exploring methods for improved care and housing of farm animals with greater economy and labor efficiency are also in progress as well as investigation of ways to modify existing structures and equipment to meet present-day economic conditions.

The agricultural experiment stations of many of the States have research underway whose major objectives involve the obtaining of information on the uses to be made of electric energy to reduce labor, increase production and improve family living conditions. In the design of these studies provision has been made to develop and investigate new equipment and explore the possibilities for new uses for electricity on the farm and in the home.

Many of the projects are concerned with the varied problems of chore labor mechanization and an expansion of the use of electricity for ventilating, heating, lighting, and cooling under the various production enterprises of today's farming operations. Development and testing of prototype specialized equipment for product collection, processing, packaging, and transport, as well as crop storage, loading and unloading devices, are a part of the overall program of investigations.

Much of the work is cooperative with the Department.

PROGRESS --- USDA AND COOPERATIVE PROGRAMS

A. Dairy Cattle Engineering.

1. Increasing Efficiency of Operations. At Davis, California, studies in cooperation with the State Agricultural Experiment Station, to determine the effectiveness of herringbone milking parlors in reducing the labor requirement in large-scale dairy enterprises were conducted. Data are being analyzed and prepared for publication. Findings to date indicate that although any size herringbone layout may be suitable for milking cows the most satisfactory sizes are: (1) a (2-4) and one operator if he also moves cows from corrals to milking area and return, (2) a (2-8) for two operators if they move cows, (3) a (2-12) for three operators if they move cows, (4) a (2-5) for one operator if he is above average, (5) a (2-10) for two operators if they are above average. Variables which have the most influence on suitability of a specified herringbone size are (1) the milking operator, (2) milking equipment, (3) milk production, (4) a cow's natural milking speed, (5) arrangement of milking area for optimum use of the above variables.

2. Bio-engineering Studies. Basic fundamental studies on the relationships between environment and various dairy animal health and production factors were continued in the psychroenergetic laboratory, and related facilities, at Columbia, Missouri, in cooperation with the Missouri Station. The investigation into the effects of total barn air conditioning for dairy cows under commercial herd practices was continued during the summer of 1966. Two groups of 16 cows were again used in a switch-back design (three-week periods, with three reversals). However, neither group was provided air conditioning in this third year of the study; the objective during 1966 was to estimate the effect, if any, of the enclosed barn and more intensive management practices when compared to the dry-lot confinement system. Results showed essentially no differences in milk production under the two confinement systems. This indicates the significant increases in milk production obtained in 1964 and 1965, when air conditioning was provided, were due primarily to the improved climatic environment rather than housing or management practices. Dairy cow activities recorded under

the two systems indicated the dry-lot cows spend less time eating during the day in hot weather. They were also more restless. Heat sensitivity studies were continued during the summer of 1966. The heat sensitivity indicator (rate of rise of rectal temperature) has more variability than desirable, leading to the conclusion that a minimum of two tests may be necessary before using the test as a basis for selection. Dairy herd owners have for many years needed a rational basis for determining the amount of shelter to provide their lactating animals. Research in the Missouri Climatic Laboratory has provided general guides by relating milk production to selected climatic variables, but such results per se do not provide a clear-cut basis for decision-making. By linking the production response of the animal to the probability of occurrence of the weather event determined from climatological records, the probability of a given production response can be found. This probability would then give the dairy herd owner a rational basis for decision. Using this approach, expected summer production losses for Holstein dairy cows of three production levels in the mid-Missouri area were computed, based on Temperature-Humidity Index records. Total expected production loss per cow for the "summer season" considered (June 1 through September 30) was determined to be:

51 lbs for 30 lb/day production level,
 88 lbs for 40 lb/day production level.
 127 lbs for 50 lb/day production level,

Thus, an owner near Columbia, Missouri, could estimate the economic potential of providing alternate methods of alleviating production decline through providing a more nearly optimum environment.

A study on the role of infused epinephrine and norepinephrine solutions in heat dissipation by the dairy cow showed both to have a strong influence on moisture dissipation at high environmental temperatures (95°F, 50%RH). At moderate conditions (65°F, 50%R.H.), epinephrine still exhibited a strong reaction, but norepinephrine did not evoke a response. Other physiological parameters were recorded, and the results are being processed.

Comparisons of volatile fatty acid (VFA) concentrations (the main fuel for rumination) were made in non-lactating cows at ambient temperatures of 18.2° and 35.0°C and intraruminal temperatures of 43.4° and 51.0°C. The 43.4°C intraruminal temperature with an ambient temperature of 18.2°C caused a highly significant increase in VFA concentrations when compared to concentrations at normal rumen temperature and 18.2°C ambient. A 51.0°C intraruminal temperature with an ambient temperature of 35.0°C resulted in a highly significant decrease when compared to the concentration measured at normal rumen temperature and 35.0°C ambient.

3. Plan Development. No plans for dairy cattle structures were developed during the reporting year.

B. Beef Cattle Engineering

1. Hot, Arid Climates. These investigations were conducted at Davis, Firebaugh and El Centro, California, in cooperation with the California Agricultural Experiment Station (Animal Science and Agricultural Engineering Departments), a beef cattle producer at Firebaugh, and the Madera County Agricultural Extension office.

A test was conducted during the summer at Davis (121 days) to study the effect of shade and animal space on beef cattle production. There were 12 Hereford steers per pen. The table below shows the treatments and a summary of results: There were no differences in animal responses in the

Pen No.	3	9	10	11	12
Pen Floor	Concrete	Concrete	Concrete	Dirt	Dirt
Pen Size	40x80 ft.	16x30 ft.	16x30 ft.	55x30 ft.	55x30 ft.
Pen area/steer	265 sq.ft.	40 sq.ft.	40 sq.ft.	138 sq.ft.	40 sq.ft.
Shade area/steer	No shade	24	No shade	24	24
Avg. Init. Wt.	618 lb.	618 lb.	618 lb.	618 lb.	618 lb.
Avg. Final Wt.	968 lb.	946 lb.	933 lb.	977 lb.	952 lb.
Feed/lb/gain	7.00 lb.	7.38 lb.	7.46 lb.	6.76 lb.	7.92 lb.
ADG	3.13 ^a lb.	2.73 ^b lb.	2.64 ^b lb.	2.01 ^a lb.	2.79 ^b lb.

a,b Differences significant ($P < 0.01$) if comparable means do not have a common superscript.

concrete or dirt pens. These results were for the summer and may not be true during wet weather. The wetness of the dirt pen may have provided some cooling effect for the dirt animals since, normally, the condition of the dirt pen with 40 ft.² would seem to add to the problems of the animal movement. The results from pens 11 and 12 show there was a significant benefit to animal gains from the large space allotment in dirt pens. What this really means is that 40 ft.² per animal is too little space under the summer conditions of this test. There may be some area in between the two used that would be equally as good as the 138 ft.². Comparison of pens 3 and 10 shows the disadvantage to gains of small area per animal over concrete. These animals had no shade. Again, it may not require anything like the 265 ft.² per animal that was used, but it is obvious that 40 ft.² was too little for the summer conditions of this test. Comparison of pens 9 and 10 show, as in past tests, that there is no advantage for shade in an area with weather like that at Davis.

Space requirements for beef cattle on concrete floors (sloping floors) were studied at El Centro. Pens of equal size had different numbers of animals. One test was started on October 5, 1966, with heifers averaging about 680 lb. each; and concluded December 28. A second test was conducted beginning February 1, 1967. The results are summarized below:

² Ft /Animal	20	40	60	Dirt (125)
Animals/pen	12	6	4	6
Av. daily gain, lb.				
1st Test	2.46	2.74	3.29	2.93
2nd Test	2.00	2.44	2.46	2.54
Mean	2.23	2.59	2.88	2.74

The data have not yet been analyzed statistically, nor is the feed conversion data available to us at this time. It seems apparent, however, that 20ft.² is not enough and there may be differences between the 40 and 60ft.² pens.

Three trials with beef cattle were conducted on a ranch at Firebaugh, California, in an effort to find a system that would relieve the winter mud problems on feedlots. Two trials were for 60 days and one was for 30 days, covering the period from April 1966 to February 1967. The floor treatments were: (a) sawdust on straw bedding, (b) straw bedding in loafing free stalls 3'x7', (c) slatted wood floor with 1-inch spacing, (d) concrete floor, and (e) standard dirt feedlot. All of the first four pens had a shade over the whole pen and a 9-ft. wide washway in front of the feed bunk. In the first trial there were 40 steers per pen, 20 in the second trial and 16 in the third trial. In the first trial, during summer months, gains in the stall pen and the concrete pen were significantly lower ($P < .01$) than all others. Gains were highest in the natural feedlot pen. Differences were small in the second trial (only 30 days and not statistically treated). During the winter trial the gains in the stall pens were significantly less ($P < .01$) than in all other pens. In comparing the two summer trials, the gains with 25 ft.² per animal were less than with 50 ft.². Stalls were used 46.5% during the day (6 A.M. - 6 P.M.) and 67.3% during the night. Stalls for beef cattle, at least as they were used here, are not the answer. More work and analysis will need to be done to determine if the other floor treatments are practical.

Use of stalls for beef cattle during winter was studied at Davis. Sixteen Holstein steers in concrete lots (400 ft²/steer) had stalls available (under shelter) and a similar number had no stalls. The same treatments were given Hereford steers. An additional group of Herefords were in a muddy pen (kept muddy by watering) with no shelter. The cattle were on

test for 178 days. Stalls did not improve rate of gain or feed efficiency. Mud, however, had a drastic effect--daily gain was reduced 27% and feed efficiency was reduced 23%. Stalls were in use 32.6% of the time during the day (6 A.M. - 6 P.M.) and 49.3% during the night. In 1440 observations (10 minute intervals) stalls were in use 100% only once, 89% only 21 times, 78% only 48 times and 67% 129 times. If stalls are used it is only necessary to provide stalls equal to 75% of the number of animals.

2. Hot, Humid Climates Inactive during reporting period.

3. Plan Development. No plans for beef cattle structures were developed during the reporting year.

C. Swine Engineering

Swine environmental studies were conducted at Davis, California, in cooperation with the Animal Science and Agricultural Engineering Departments of the California Agricultural Experiment Station.

1. Effect of Humidity on Swine. Humidity tests started in 1963 were continued. Two tests were completed with pigs at air temperatures corresponding to maximum gain temperatures (MGT) plus 10°F. Six tests have now been completed, three at MGT and three at MGT + 10°F. In the two tests this year pigs were raised from 85 lb to market weight at MGT + 10°F and either 30, 60 or 90% RH, nine Durocs per test, three pigs at each condition during each test. The results are summarized below for both tests. The difference in gains between the high and low humidity was highly significant ($P < .01$). Feed efficiency was about the same. There were no significant differences in skin or rectal temperatures for either test.

Relative humidity, %	30	60	90
No. of pigs	9	9	8
ADG, lb/pig	1.28	1.17	1.08
Feed consumed, lb.	4.46	4.00	3.90
Lb. feed/lb gain	3.50	3.53	3.65
Rectal temp. °F	103.9	104.3	104.3
Skin temp. °F	95.0	94.5	95.2

2. Sprinkling of Swine The effects of sprinklers on skin and rectal temperatures, respiration and pulse rates were studied in a series of 18 tests under various conditions. The data have been only partially analyzed and will be reported later.

3. Swine Exercise. Two pens of Duroc gilts averaging 112 lb. each to start were housed in the barn at Davis, with concrete floors. The pigs in one pen were exercised at 9 A.M. and 4 P.M. by walking twice the length of a concrete alley about 300 ft. in length (about 22 minutes per day). The exercised pigs gained at a significantly lower rate ($P < .05$) than non-exercised pigs. Feed required per pound of gain was not different.

4. Nutrition and Environment of Swine. Twenty six pigs (3 litters) were weaned at two weeks of age and fed a semi-purified diet containing a low level of vitamin A for 4 weeks. The pigs were then separated according to litter, sex and weight. Five pigs were killed and liver samples were taken for vitamin A analysis. Five pigs were allotted to each of the following treatments:

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- a) Temp. 75°F, 400 IU vitamin A/lb feed
 - b) Temp. 105°F, 400 IU vitamin A/lb feed
 - c) Temp. 105°F, 1600 IU vitamin A/lb feed
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There were no differences in rate of gain during the first five weeks. After five weeks, the pigs housed at 75°F gained significantly ($P < .01$) faster than pigs housed at 105°F regardless of the vitamin A content. Increasing vitamin A content of the diet did not improve the rate of gain of pigs housed at 105°F. Temperature did not appear to affect feed utilization as measured by the amount of feed required per unit of gain. The average rectal temperature of pigs housed at 75°F was significantly ($P < .05$) lower than for pigs housed at 105°F (103.9F vs 104.8F and 104.5F). Increasing vitamin A content of the diet increases the vitamin A storage in the liver. There was no difference in liver storage of vitamin A between pigs fed 400 IU per lb. feed and housed at 75°F or 105°F. This trial will be repeated later after the next humidity test.

5. Music for Pigs. Sixty Duroc pigs averaging 77 lb. were assigned to 22'x8' outside pens with concrete floors. Shades over the pens were of corrugated steel. A radio was situated so that pigs in two of the pens would hear it but pigs in the other two could not. The radio was tuned to a station that was on the air 24 hours a day and primary programming was music. Behavior was observed every half hour between 8:30 A.M. and 4:30 P.M. every Tuesday and Thursday for 3 weeks. The numbers of pigs eating, resting, and standing (but not eating) were counted. The trial was conducted for 11 weeks during July and August, 1966. Playing radio music did not affect behavior or performance of the pigs. The lack of response to music in the present trial does not preclude the possibility that situations exist where music is beneficial. Some producers feel that music helps prevent startling of pigs by visitors or sudden noises. At the

University hog barn this benefit would be minimal because the pigs are used to the many visitors to the hog barn. Music did not have any effect on the feeding patterns. The periods when the greatest number of pigs were observed eating were 10:30 - 11 A.M. and 1 - 2 P.M.

6. Plan Development. At Beltsville, Maryland, in cooperation with the Southern Regional Plan Exchange, Plan No. 5992, "Farrowing and Growing Building," based on a Virginia plan, but modified and developed, was published by the Cooperative Farm Building Plan Exchange for distribution nationwide.

D. Poultry Engineering

Poultry house environmental design criteria were investigated in controlled laboratory studies at Beltsville, Maryland, in cooperation with AHRD. The criteria were field tested in poultry houses in cooperation with the West Virginia Agricultural Experiment Station at Wardensville. Environmental influences on health and housing were investigated in laboratories at Athens, Georgia, and State College, Mississippi, in cooperation with AH, ADP, ARS, and the respective State Agricultural Experiment Stations. At St. Paul, Minnesota, in cooperation with the Minnesota Agricultural Experiment Station, the importance of environmental stress in relation to turkey diseases and growth was investigated.

1. Calorimeter Studies at Beltsville. Heat and moisture and other biological data necessary for designing broiler house insulation and its ventilating systems were developed in the calorimeter at Beltsville and successfully applied to two experimental broiler houses in West Virginia. The field studies were made in pens containing 1200 to 5000 growing broilers. In 6 week-long tests analyzed, the amount of ventilated moisture agreed to within 90% of the moisture removal as calculated by using the Beltsville broiler data. A seventh test, of 3-day duration, for chicks 1 to 4 days of age showed ventilated moisture 49% greater than the calculated figure. The calculated moisture removal of the six tests ranged from 16 to 66 lbs/hr. and involved broilers 7 to 60 days of age. The sum of total heat ventilated and lost through building conduction of the six week-long tests was 1.5% to 15% short of calculated figures. The greater disagreement occurred for a group of 5000 broilers 42 to 49 days of age. One other result with 1200 broilers 56 to 63 days showed 12% greater heat output than the calculated figure. These total heat comparisons involved calculated heat of 13,000 to 175,000 Btu/hr.

Field studies involving accurate measurement of ventilation and hygrometric data are difficult to establish with wind, solar and barometric pressure variables. Additionally, when broilers were 35 days of age and older, it was difficult to obtain "representative" litter samples from litter with variable moisture content and thickness. Despite these problems, the

Beltsville broiler data can be applied to broiler houses and obtain ventilated heat and moisture outputs to come within 10 to 15% of the calculated figures.

2. Southeast Poultry Research Laboratory. The primary engineering activity at this laboratory was still concerned with development and procurement of specialized equipment and instrumentation necessary for studies with diseased poultry. An additional environmental cabinet (making a total of 5) was completed and installed with control panel, in one of the climatic chamber buildings along with the four other cabinets previously completed. Completion of this work provides a versatile environmental cabinet facility for poultry disease research where, under protective conditions, air temperatures and humidities, enclosure temperatures, ventilation and air circulation rates and air quality may be programmed or varied as desired.

A second type of environmental cabinet of somewhat simpler design and construction than those referred to above was constructed, tested without controls, and modified to meet specified requirements.

3. South Central Poultry Research Laboratory. Engineering research was continued in studies of the effects of construction, equipment and management of poultry housing structures on broiler diseases and condemnations, in cooperation with AH and the Mississippi Agricultural Experiment Station.

A warmer winter temperature and a lower summer radiant heat load can be maintained in broiler houses that are insulated. Very little decrease in condemnation resulted from growing broilers in insulated houses but there was a better feed conversion. An expandable brooder-broiler house was developed that gave satisfactory performance. This type house gave a 30% saving in fuel over the regular insulated house during the winter period.

Chicks brooded at weekly temperatures of 1st week - 85°F, 2nd week - 80°F, 3rd. week - 70°F, and 4th week - 60°F, had as good body weight and feed conversion at the end of the 4th week as chicks brooded at a weekly temperature of 1st. -95°F, 2nd - 90°F, 3rd - 80°F, and 4th- 70°F. Chicks grown out under a fluctuating diurnal temperature between 40° - 80°F and those grown under a constant 60°F had approximately the same rate of body gain, feed conversion, and mortality. Condemnation was slightly higher for the birds grown under the fluctuating temperature. The rates of air exchange between 0.5 and 3.0 cfm/bird had little effect on the condemnation and performance of broilers. The chicks grown in the lower ventilating rates tended to have the lower body weight.

Amount of air passage through woven plastic curtain material varied with pressure differential as well as the method of manufacture of the material. The amount of air passage could be critical for broilers with

outside high wind velocities and low temperatures. Under the temperature conditions studied, very little water vapor was transmitted through 15# felt paper or the lap joints.

4. Influence of Turkey Housing Environment on Disease. The influence of housing and environmental stress on incidence of turkey diseases was investigated at St. Paul, Minnesota. Three experiments were conducted with turkey fryer roasters. One objective of the experiments was to determine the possibility of eliminating the N strain of mycoplasma by dipping the eggs in an antibiotic. Two of the flocks remained negative to the disease throughout the experiment. The poults were reared in two pens having different environmental conditions. The South pen has a concrete floor, supplemental heat, and a horizontal ceiling. Birds in this pen continued to have a slight edge over those in the North pen, which is similar to turkey houses used commercially.

Removal of litter moisture by means of vapor pressure differences looks promising as does brooding with electric radiant energy sources supplemented with hot water perimeter heating. Designs of turkey facilities to study the environmental aspects of Bluecomb and Salmonella in turkeys are under way.

5. Eggshell Strength. During the past year a quick, non-destructive method of measuring eggshell strength was developed. It is expected to decrease the \$25 million annual loss in broken eggs. The method utilizes a weak source of radioactivity, whose radiation is reflected or back-scattered by the eggshell. This backscattered energy is received for 5 seconds by a Geiger-Mueller tube which actuates a counter. The counter reading is not thickness, but a strength index based on density and thickness. This equipment might be used by hatchers to eliminate weak-shell laying strains, by shippers to eliminate weak-shelled eggs, and by designers of egg-handling equipment who need shells of known strength.

6. Plan Development. At Beltsville, Maryland, in cooperation with the Northeastern Regional Plan Exchange subcommittee on poultry, Plan No. 6000, "Poultry House-Floor Management," originally designed by Connecticut, was included in the Cooperative Plan Exchange and released for national distribution.

The same committee approved Plan No. 6001, "Poultry House-Cage Management," designed by Connecticut and distributed nationwide.

E. Extracorporeal Irradiation of Farm Animal Blood.

1. Development of Apparatus. A simulated blood circulatory system consisting of plastic tubing and a pump (heart) has been designed for use in studies on extracorporeal irradiation of blood to be conducted at the National Animal Disease Laboratory, Ames, Iowa. An irradiator for use in the studies is being developed by the Oak Ridge National Laboratory, AEC.

F. Radiosity Studies.

Radiant fluxes from the sky, ground, and surroundings are being measured at Davis and other points in California and at Columbia, Missouri, in order to evaluate the radiant environment of livestock.

1. Radiation Under Poultry Brooders. Last year an investigation was made of the use of ping pong balls as black globe thermometers to measure radiant heat loads. These were used to investigate the radiant heat loads under typical poultry brooders. One brooder was a floor model Lyons Electric brooder 56 inches in diameter. Ten globe thermometers were spaced on 6-inch centers on a diametral line 1-1/2 inches above the floor. At a second location, 6-sided gas brooders were used (Big Dutchman) on a raised, stretched-wire floor. Globes were placed at various locations over the brooder floor to represent chicks at various locations. Day-old chicks were put into two of the four quadrants under this brooder and their activity was recorded with cameras.

Radiant heat loads varied from 147 Btu/hr ft.² at one edge to 165 Btu/hr ft.² at the middle. Such variations were common and, perhaps, the variation is good. At least a chick has some choice in environment. The point of concern is the variation during the day. For example, the globe temperature varied from 98.5°F when the outside air temperature was 68°F to 79°F when the air was 42°F. There seems to be a need for improvement of controls for such brooders. These tests will be continued.

G. Reducing Pesticide Residues in Animal Products.

1. Automatic Sprayers. Emphasis during 1966 has been on the ultra-low volume (ULV) application of insecticide to cattle, in cooperation with ENT. The results of laboratory tests, field studies, and insecticide residue in milk studies indicate that the ULV technique has considerable potential as a means of reducing the hazards associated with chemical control of livestock insects. In laboratory tests it was found that the application of Ciodrin^R, Malathion, Sevin^R, or GC-4072 at a rate of 1 ml twice daily in concentrations of 0.5% to 1% is capable of protecting cattle from the horn fly.

ULV automatic sprayers performed satisfactorily under field testing despite problems due to incompatibility of the insecticide solvent and valve seal material. Two of these sprayers operating at 150- and 300-cow dairies gave essentially complete horn fly control for the five month test period. The results of these tests indicate that 1% Ciodrin in xylene applied at a rate of 1 ml twice daily is sufficient for controlling the horn fly on dairy cattle.

A study was conducted to determine the potential of the ULV techniques in reducing insecticide residues in milk. No Malathion residue was detected in milk samples taken from 2 dairy cows sprayed with 1 ml twice daily for 21 consecutive days with 2% and 5% Malathion in xylene. Ronnel applied in like manner at concentrations of 5% and 10% resulted in residue in the milk beginning with the first day's spraying. There was a continuous buildup of ronnel in the milk through the 28 treatment days.

A study of the spray distribution on cattle resulting from treatment with the ULV sprayer indicated a much improved distribution pattern over that obtained with the previous 1 ml pneumatic atomizing sprayer. Although the application is made in a one foot wide band from the wither to the loin on only one side of the animal, at the end of seven consecutive treatment days it was observed that insecticide had been translocated to nearly all parts of the animal. Attempts to quantify the photographic records used for the distribution study have been encouraging.

2. Significance of Hair Loss. A study to determine the significance of hair loss as a factor contributing to insecticide loss has yielded data indicating the seasonal cyclic patterns of hair growth and loss on a cow for a complete year. Hair loss during the early summer reached a peak of 0.89% per day of the total quantity of hair on the cow. Such a loss could account for an equal percentage loss of insecticide from cattle during this season.

3. Fly Flight Activity Patterns. Modifications and improvements were made on the system for detecting the flight activity of biting flies affecting livestock. Progress was not as anticipated for the year due to problems with humidity control in the system. The results of preliminary tests hint that there may be a repeating rhythm in the activity of the stable fly. Studies dealing with the feeding activity of horn flies and stable flies were initiated. This work is in cooperation with Projects ENT-h2-1 and ENT-h2-23.

4. Southwestern Veterinary Toxicology and Livestock Insects Research Laboratory. Facilities for the engineering research program that will apply engineering and physical sciences to obtain basic data on biophysical instrumentation and environmental effects for use in studies of animal and insect toxicology and biophysical responses of organisms to chemicals and in the planning stage.

H. Water Supply and Wastes Disposal

1. Farmstead and rural water systems. Studies on farmstead and rural water supply systems design criteria are continuing in Maryland in cooperation with the Maryland Station and selected farmers. Water use data were collected at three additional farms during the year, using a portable

intermediate storage water system at two of them where demand exceeded source yield for two hours. At the third farm a large 23,000 gallon intermediate storage system was already installed. All data collected conformed closely with previously determined demand-duration data. Declining ground water yields due to extended drought further proved the value of intermediate storage systems. A study was made of minimum well construction standards and frost heave to help eliminate differences in USPHS requirements for well construction affecting dairymen producing milk for interstate shipment. Considerable time was devoted to developing a revision of the water supply plumbing design appendix for the National Plumbing Code. The design recommendations are being changed to a system of velocity limits based on water quality and limiting noise and water hammer. A simplified method was developed for estimating peak water demand rates in the home using the data collected and an analysis procedure developed by the NBS.

2. Farm animal wastes disposal. Laboratory and field studies are continuing in Maryland, in cooperation with the Maryland Station and selected farmers. An outdoor hydroponic bed was installed to field check earlier laboratory findings that hydroponic techniques could be employed to remove plant nutrients (N,K,P) and trace minerals from manure lagoon effluents and thus avoid "feeding" algae and other undesirable aquatic growths in receiving waters. Observations to date indicate the bed will satisfactorily extract the nutrients and provide a good stand of grass that can be harvested for feed. Analyses and evaluation over a growing season have not yet been made. Observations over the winter and early spring showed continuous extraction of copper and other trace minerals and good early growth recovery of perennial grasses. Work on air filtration in an effort to control odors in poultry houses showed a relationship between poultry house dust and persistence of odors. Dust picked up on a ventilating fan filter pad retained a noticeable "poultry" odor for more than 6 weeks, while air passing out through the pad carried a noticeable ammonia odor.

An engineering feasibility and cost analysis of elements deemed to have most promise of successful incorporation into commercial enterprises for poultry manure disposal and associated odor control was initiated under Cooperative Agreement dated January 31, 1967, with the Agricultural Experiment Station of Cornell University. No reportable progress to the end of the reporting period.

I. Farmstead Planning.

1. Farmstead model layout studies. Studies in cooperation with the Minnesota Experiment Station on the use of scale models for analyzing farmstead layout problems were completed and a report prepared for publication. The work demonstrated that scale models can prove valuable aids in farmstead planning, but need to be supplemented by some numerical analysis.

2. Chore time standards At the Minnesota Experiment Station a usage study of a free-stall, slat-floor, dairy housing system, both insulated and uninsulated, with outside feeding, showed that in cold weather the animals stayed in the stalls at night from dusk to dawn, and during the daylight hours on those days when it was snowing and/or windy. In the summer and fall they used the stalls in the afternoon to escape the heat, but usually remained outside at night. Approximately one-third of the manure was dropped inside and could be pumped from the pits as a liquid about eight months of the year. In the coldest four months, the manure in the pits and on the slats was frozen so that it had to be scraped from the slats and handled as a solid. In the winter it was necessary to clean manure droppings from 60 to 70% of the stalls each day. In the summer, this problem was not as great, as the animals spent more time standing on the slatted-floor alley than in the free-stalls. The use of heat lamps in the insulated unit to induce the animals to spend more time inside on sub-freezing days was not effective in keeping the manure on and under the slats from freezing. Observations of the equipment arrangement in the outside feeding area indicated that the location of the waterers, silage, and hay bunks had no apparent effect on the amount of time the animals spent inside the housing units.

3. Animal response to sonic boom. In cooperation with AII and Biometrical Services Staff, AE participated in a study supported by the National Sonic Boom Program, USAF, and the NAS to determine the effects of the sonic boom on mink production. Work during the reporting period consisted of preliminary planning, site selection, review of technical literature and adaptation of a sonic boom simulating device.

J. Physical Methods for Fly Control

At Beltsville, Maryland, investigations of physical methods for control of flies were continued with cooperation of Entomology, Animal Husbandry, and Agricultural Engineering Research Divisions, ARS.

Studies of the effectiveness of farmstead sanitation in reducing fly populations were continued and confirmed previous findings that significant population reductions (about 1/3) can be achieved by sanitary measures on a single farm when unsanitary farms are as close as 1/2 mile away. Data on re-capture of released marked flies indicated that flies disperse primarily upwind and to "dirty" areas with many possible breeding sites, rather than to "clean" areas. Similar sanitation studies conducted under contract by Louisiana State University on selected farmsteads also indicated reductions in fly population to be directly related to the level of sanitation maintained.

In evaluation trials of existing fly-control devices including electrocutor grids, electrocutor grids plus light attractants, and attractant-toxicant devices (ultraviolet attractant lamps behind a gauze curtain treated with a

contact insecticide), all proved virtually ineffective when used outdoors in cattle pens. Numbers of flies killed were insignificant and unlighted grids were as effective as lighted ones, indicating random flight to all units. Three types of attractant-toxicant devices tested inside barns killed slightly larger numbers of flies than when used outdoors.

Further tests of the responses of house flies and face flies to various wavelengths of electromagnetic radiation indicated that type GRO (Gro-Lux) lamps to be more attractive than would be suspected from their appearance to human vision, but less attractive than "blacklight" ultraviolet. When ultraviolet lamps were cycled "on" and "off" for varying proportions of time the numbers of flies collected increased as the "on" cycle lengthened, indicating no benefit from cycling. The response of houseflies in a lighted environment to various attractant wavelengths appeared to be affected by both temperature and sex. At low temperatures (65° F.) the catch is predominantly males and longer wavelengths - green, yellow, and orange - seem more attractive than ultraviolet. At high temperatures (90° F.) the catch is predominantly females and short wavelengths - ultraviolet and 4000 Å blue - seem most attractive. Limited tests with infrared radiation indicated that flies readily detected and followed currents of warm air but were not attracted by direct infrared radiation.

A test of residue accumulation problems from feeding larvicides to dairy cattle was begun in cooperation with the Dairy Husbandry Research Branch. Various larvicides will be used in long-term feeding trials and the residue in milk and animal tissue carefully assayed. Facilities are being expanded to accommodate this work.

K. Equipment for Livestock and Poultry Feeding

Cattle Feeding Equipment

At Urbana, cooperative with the Illinois Agricultural Engineering and Dairy Science Departments, an automatic dairy cattle feeding system is being developed. This system will serve as a mechanization center for the study of the management and equipment interaction and for the development of an efficient overall system.

Work at the present time is concentrated on a materials handling system capable of full-automatic or manual operation. This system is made up of components developed in earlier research work on poultry, hog, and beef cattle feeding systems. The interdependence of controls and equipment was accentuated in this system. During the past 2 years, the major effort was to improve the reliability of the equipment. A metering device using a variable-speed DC motor controlled by a silicon controlled rectifier circuit proved a satisfactory means of metering concentrate on silage. A uniform

discharge rate from an automatic silo unloader is required for a satisfactory feeding system. This has been difficult to achieve. However, a new system was developed that controls silage discharge rate to the acceptable accuracy of plus or minus 10 percent variation when used with a 2-motor top-unloading silo unloader. With a 1-motor silo unloader the variation in discharge rate is 15 to 20 percent.

A project was started to develop a pilotless and automated feed wagon capable of moving about over a programmed course and performing specified operations while following the course. The present means of guiding this vehicle is a buried cable carrying a discrete alternating current. A detector on the vehicle locates the cable and keeps the vehicle centered over it. Initially, the vehicle was to be powered with electric motors. The energy requirement (100 kw.-hr.) was too great to be handled by present storage batteries; therefore, a gasoline engine with a hydrostatic transmission was used. The hydrostatic transmission permits smooth and continuously variable speed control of the vehicle. On-board equipment will be operated either by small electric or hydraulic motors. The vehicle will be subject to three modes of control: first, automatic programmed operation with instructions transmitted over the buried cable; second, manual control with an operator riding on-board the vehicle or walking to its side; and third, radio control which will be similar to manual control except that the operator can be far removed from the vehicle.

A pilotless vehicle will be especially useful on large feed lots where mechanization with augers and conveyors is not feasible. It will be useful for many other purposes on farms such as hauling material from field to storage, transporting workers in the field for harvesting purposes, or pulling or operating equipment over a prescribed path such as in a field or orchard where it could be used to spray trees.

During the past 3 years at St. Paul in cooperation with the University of Minnesota Agricultural Engineering Department, tests were made of the performance of electric motors currently being recommended for unloaders for vertical silos and for feed bunks. During this time six motor manufacturers submitted motors for testing. Five of them incorporated some of our results in designs for new motors. These tests were terminated during the past year. The performance requirements for the above motor applications have been fairly well established, and the dynamometer used for the tests had to be released for student class work.

At Pullman, in cooperation with the Agricultural Engineering and Animal Science Departments of Washington State University, work was renewed in February 1966 on an automatic horizontal or trench silo unloader. The automatic horizontal silo unloader previously developed was improved and a redesigned cutter unit was installed on the equipment. This new cutter is capable of faster removal of silage with less power than the original cutter

and avoids some of the throw-down and scatter problems found with the old design. New controls for the system were incorporated which increase the unloader's ability to perform automatically and overcome the difficulty in controlling the lowering and advancing steps.

L. Electric and Solar Equipment for Environmental Control

Equipment for Poultry Environmental Studies

In cooperation with the Poultry Research Branch at Beltsville, Maryland, the fifth year of a 5-year genetic selection of laying stock responsive to less than a 24-hour-day cycle was completed. Five years' summary shows the following results: (1) 18- and 24-hour selected populations showed advantages in egg production over the controls of 8.1 and 6.2 percent, respectively, in the four generations; (2) realized genetic progress obtained by a system of hen family and individual selection was greater than anticipated under both environments; and (3) birds matured earlier with a constant 6-hour photoperiod than with a step-down program under an 18-hour environment. The egg production curve of 18-hour population shows that these birds did not come into production as soon as those in the 24-hour population and suggests that in future "short day" studies their age at sexual maturity should be decreased by giving them additional exposure to light.

The electronic data-recording system used in the above study showed an overall 5-percent error in recording time of lay for 95,932 eggs from both houses (18- and 24-hour). This involved 785 hens for six 30-day laying periods. Four major sources of error were (1) eggs not rolling down cage floor to activate egg sensor, (2) eggs rolling under or over sensor arm, (3) sensor not resetting properly, and (4) error, but no visible cause noted at egg collection.

At the Southeast Poultry Research Laboratory, Athens, Georgia, four air velocity/heat tolerance tests were conducted as a followup to last year's studies. Three tests were at air temperatures less than 100° F. and one greater than 100° F. In each of the tests, six birds were placed in an air stream with a velocity of approximately 20 f.p.m. and six at approximately 500 f.p.m. velocity. At air temperatures less than 100° F., heat stress was alleviated by the higher air velocities, as indicated by lower body temperatures, heart rates, and respiratory rates. The opposite occurred at air temperatures greater than 100° F., as the respiratory rates and body temperatures increased more at the high air velocity than at the low. Heart rates were only slightly affected by air velocity.

Considerable engineering effort went into the design of research equipment and facilities for the Southeast Poultry Research Laboratory. Model III isolation cabinets were designed and 72 were purchased. Accessories for 36

of these cabinets were designed and installed. Equipment was designed and installed to provide filtered positive-pressure ventilation in two additional poultry houses. Five old isolation cabinets were converted to positive pressure for producing disease-free chicks. Five long-life, dust-tight psychrometers were designed and built. A precision air flow calibrating system was designed and built. Implantable radio telemetry equipment was built and tested.

At the South Central Poultry Research Laboratory, State College, Mississippi, one of the existing poultry houses was converted into a windowless unit with controlled temperature, humidity, light, and ventilation. Operation of this facility indicates that close control of humidity and ventilating rate is necessary to control dust and ammonia, and that these requirements are drastically affected by bird density. Direct control of the ventilating rate by exhaust dew-point temperature appears to offer advantages over control by relative humidity-temperature systems. Environmentally controlled chambers have been designed and procured which should reduce problems inherent in recirculation-type chambers.

In the studies to determine the effects of exposure of broilers to temperature extremes, results show that broilers relatively disease-free or infected only with Mycoplasma gallisepticum can withstand severe temperature extremes if the duration is short. Such exposures do not significantly affect mortality, condemnation, or 8-week body weights. The conclusion drawn from this work is that temperature alone is not the stress factor which it is generally thought to be. This should open the way for studies to determine what other factors are important stresses, and how these factors might be affected indirectly by temperature.

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II. NUTRITION, CONSUMER USE, AND UTILIZATION RESEARCH

NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS

Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of food available to consumers change constantly with the adoption of new practices of production, processing, and marketing. Changing constantly also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, on the nutrient and other values of foods, and on ways to conserve or enhance these values in household and institutional preparation and processing.

The kinds and amounts of foods consumed by different individuals and population groups must be determined periodically so that the nutritional adequacy of diets can be evaluated. Information on food consumption and dietary levels provides the guidelines needed for effective consumer nutrition programs. This information also furnishes the basis for market analyses for different commodities and for development and evaluation of agricultural policies and programs that relate to production, distribution, and consumer use of food.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of improved procedures for household food preparation, care and preservation; (3) nutritional appraisal of food supplies and diets of different population groups; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition Research Division at Beltsville, Maryland, and the Consumer and Food Economics Research Division at Hyattsville and Beltsville, Maryland and Knoxville, Tennessee. Some of the research in both divisions is done under cooperative, contract or grant arrangements with State Experiment Stations, universities, medical schools, hospitals, research institutes, and industry. The total Federal scientific effort devoted to research in these areas is 81.7 man-years. It is estimated that 11.2 scientific man-years is concerned with studies related to animal products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis,

though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 19.8 scientific man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to animal products are considered briefly in this report.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Nutrient and Other Consumer-Use Values of Animal Products

1. Beef. Studies under contract at the University of Wisconsin at Madison on the fatty acid composition of beef are continuing. Biopsy samples of the Longissimus dorsi muscle of fifteen animals were taken at 12 months of age and at 2 month intervals thereafter. These data showed an increase in extractable intramuscular lipid, largely in the neutral fat rather than phospholipid fraction, as the animals increased in age and weight. A paper based on part of these studies was prepared to be given at the August 1967 meeting of the American Society of Animal Science. In addition, fatty acid analyses of raw and cooked cuts from 6 out of the 12 animals planned for the study have been processed. Slaughter weight was about 1,000 pounds live weight.

A study was made to select the best method for extracting lipids from meat samples. Meat lipids were more completely extracted by chloroform-methanol than by either acid hydrolysis or Soxhlet extraction with volatile solvents. Comparisons were made both of total lipid and of phospholipid extracted. Variations in sample preparation such as freeze drying, vacuum or air drying, grinding, or grinding and homogenizing did not affect the extraction of lipids. Acid hydrolysis resulted in a decrease in the total amount of extractable lipids and phospholipids. The manuscript reporting these studies was published.

Statistical analyses of data showed that the effect of broiling treatment upon color and tenderness of 1-1/2 inch steaks varied among seven beef muscles tested. For instance, soluble pigment content of the Longissimus dorsi muscle in rib steaks decreased significantly with an increase in broiling time when broiled at 350° F., but not when broiled at 250° or 450° F. On the other hand, the soluble pigment contents were similar for chuck steaks (Triceps brachii or Serratus muscles) broiled at 250°, 350°, or 450° F. for 15, 20, or 25 minutes. Under comparable broiling conditions, chuck steaks were about as tender as rib and loin steaks, and round steaks (top, bottom, and eye of round) were much less tender than either. With an increase of 100° F. in broiling temperature or 5 minutes in time, steaks from bottom round increased in tenderness, whereas those from the rib and loin became less tender. Steaks were scored medium when broiled to an internal temperature of 140° F. This final internal temperature is usually associated with a rare degree of doneness in rib roasts and illustrates the difficulty of applying results of research on meat prepared by one method of cooking to all other cooking methods. Manuscripts presenting these data are being prepared.

2. Beef and pork. Cooking of ground beef or pork patties did not greatly change the fatty acid composition according to studies done under a research contract at the University of Tennessee at Knoxville. Analyses were made of the extracted lipid from raw meat, cooked meat, and drippings. The lipids were separated into neutral fat and phospholipid fractions. Polyunsaturated fatty acids were largely in the phospholipid fraction; cooking increased the phospholipid concentration of the ground meat. This could be explained by the loss of larger amounts of neutral fat to the drippings, causing an apparent gain in phospholipid in the cooked beef or pork. However, the beef and pork were relatively low in phospholipid, less than 5 percent of the total fat or less than 1 percent of the meat, and were also low in unsaturated fatty acids.

3. Pork. Data have been obtained from 10 of the 24 pigs planned for the study of the fatty acid composition of uncooked and cooked fresh and cured pork, done under contract at the University of Missouri at Columbia. Cooking decreased the unsaturated fatty acids of the phospholipid fraction of lean pork. Results of these studies on 9 animals were submitted in a thesis at the University of Missouri Graduate School in partial fulfillment for a Master's degree.

The study of the effect of cooking on pesticide residues in pork has been continued. Pork shoulder cuts and loin cuts have been cooked and malathion, DDT, and heptachlor analyses are being made by the Entomology Research Division. The research is being done in cooperation with the Animal Husbandry and Entomology Research Divisions.

4. Lamb. Raw and cooked leg and rib-loin cuts of lamb showed an increase in relative amounts of separable fat and drippings with an increase in weight of cut. Separable lean contained about 90 percent of the protein and moisture of the entire cut, but only about one-quarter of the total lipids. The lean also contained most of the ash. Altogether 60 cuts each of raw and roasted lamb from 118 animals of different ages were analyzed. Cuts were separated into lean, fat, bone, and waste. Drippings from the cooked cuts were included. Analyses were made for moisture, protein, fat, and ash. Amino acids were determined in lean tissue only. Two manuscripts were published: One on the physical and chemical composition of lamb cuts and the other on the amino acids of raw and cooked separable lean tissue.

5. Meat safety. Studies have been initiated on the protection of food supplies from harmful microorganisms. Disruption of metabolic pathways in bacteria can inhibit both their growth and their toxin production in meat and meat products prone to spoilage. Procedures designed to disrupt glycolytic activity and fatty acid synthesis in Staphylococcus aureus are being developed. A manuscript is being prepared describing experiments with biotin and chloroquine that resulted in altered lipid synthesis and glycolytic activity in S. aureus.

6. Turkey. Changes in the eating quality characteristics of Beltsville Small White turkeys stored up to 10 months at -5° F. appeared to relate to different roasting times required to reach the internal end-point temperature. The frozen-stored turkeys, after being thawed to room temperature, required a longer cooking time to reach a given end-point temperature than fresh-unfrozen turkeys. This longer cooking time for the frozen-thawed turkeys resulted in higher moisture losses and produced more tender, mealy meat in the frozen-stored as compared to the fresh-unfrozen turkeys. The data suggest that eating quality of fresh and frozen-thawed turkeys would be more alike when turkeys are cooked for equal periods of time rather than to the same internal temperature. If fresh and frozen-thawed turkeys are cooked for equal times, the internal temperature to indicate optimum cooking for frozen-thawed turkeys would be about 10 degrees lower than that recommended for fresh turkeys.

Quantitative changes in raw muscle proteins of the fresh and frozen-stored turkeys as separated from extracts made with KCl-Borate buffer or with de-ionized water were not marked. A decrease in actomyosin nitrogen of pectoralis major muscle was noted as well as an indication that some proteolytic changes had taken place during storage. It does not appear that the marked changes in eating quality characteristics of frozen-stored turkeys stem from these changes in the muscle proteins. Other biochemical systems that may be responsible for these palatability changes will be investigated. A manuscript describing this research is being prepared.

7. Cheese and dairy products. A study has been initiated on the nutrients in cheeses and other milk products. Part one of the study includes products from fresh whole milk such as dried whole milk, fluid skimmed milk, dried skimmed milk, cottage cheese and whey, cream and cream cheeses, and the original milks from which the products were made. Plans are to repeat the study in two geographic locations and in each of two seasons.

In part two, cheeses of the American type cheese, i.e., Cheddar, stirred-curd Colby, Swiss; Italian types of cheese, i.e., pizza or low-moisture Mozzarella, Provolone, Ricotta, and Blue cheeses are to be obtained in two seasons. The milks from which the cheeses were made and the resulting wheys will also be obtained and analyzed.

In part three, natural and processed cheese available to the consumer in markets in each of six widely separated locations in the United States will be obtained. At any location three common or usual brands of the particular cheese will be combined. Proposed for multinutrient analyses are hard cheese, i.e., Cheddar, Colby, Swiss, Provolone; semisoft cheese, i.e., Blue, Brick, Meunster; soft cheese, i.e., Cottage cheese, cream cheese, Ricotta, Camembert, Neufchatel, low-moisture Mozzarella (pizza cheese); and processed cheese, i.e., American Brick, and Swiss. The nutrients to be assayed include cholesterol, individual fatty acids, vitamin A, carotene, several B vitamins, mineral elements, and the individual amino acids. The samples will be procured and the analyses made by Hazleton Laboratories at Falls Church, Virginia.

The Consumer and Food Economics Research Division is cooperating with the Human Nutrition Research Division in this study which will provide data needed for revising Agriculture Handbook 8.

B. Nutritional Evaluation of Animal Products

1. Heated and oxidized fats. Research to determine the effect on physiological response of aerating fats and oils at 140° F. for 40 hours has been completed under a research contract with Columbia University at New York City. The fats constituted 20 percent of each diet with all other dietary ingredients remaining constant. In addition to the results reported in the 1966 report, evidence was obtained to suggest that certain fats and oils contain substances that aggravate the development of enlarged thyroids in rats when diets contain marginal amounts of iodine. Olive oil produced a high incidence of thyroids weighing more than 100 mg., in comparison with normal thyroids of 23-31 mg. When the diet contained butter, lard, or beef tallow, the incidence of large thyroids was low. Chicken fat, soybean oil, and corn oil were intermediate in their effect on thyroid size. Thyroid size was not influenced by mild oxidation of the fat consumed.

Long-term feeding studies of diets containing fresh cottonseed oil, corn oil, lard, or hydrogenated vegetable oil or these same oils heated for 120 hours at 360° F. have been completed under contract with Swift and Company at Chicago, Illinois. Tissue masses from the animals fed these diets were evaluated microscopically at Beltsville. Mammary tumors occurred in approximately 50 percent of the female rats, an incidence similar to that reported by others for the aging rat. Their presence appeared to be unrelated to the source of the fat fed and no differences between fresh and heated fat were observed. The incidence of non-mammary tumors was relatively low, amounting to 15 percent, too few to establish any significant dietary differences. A paper reporting these findings has been prepared for publication.

2. Insecticides and dietary fat. Under a cooperative agreement with Columbia University at New York City, rats were fed lard from hogs that had been fed rations containing insecticides. The lard was supplied by the Animal Husbandry Research Division. The insecticides under investigation included DDT, malathion, and heptachlor. Results of the feeding studies are being evaluated to determine the influence of the experimental rations on growth rate and on organ size, tissue structure, and insecticide content of the tissues from animals 200 and 350 days of age.

Research has continued under contract with Swift and Company at Chicago, Illinois, to determine reproductive performance of rats fed diets which include different kinds of fats with and without a mixture of chlorinated hydrocarbons, fat soluble insecticides. Fats commonly used in food preparation were fed and include lard, cottonseed and soybean oil, and a hydrogenated vegetable fat. The level of the insecticides fed did not exceed currently accepted tolerance levels. The results already obtained with the parent and first generation indicate the importance of investigations to determine

possible carry-over effects of diet to succeeding generations. Final evaluation has not been completed but there appear to be substantial differences in response to the various fats. In addition, the response to the insecticides may differ with the kind of fat fed and with the number of generations that have received the diet containing the insecticide.

3. Immunoproteins and protein status. Research is showing how dietary protein influences the ability of the body to produce antibodies, a function of the body essential to health. A study currently underway is directed toward determining the influence of protein quality on antibody production and to learn if antibody production can serve as a measure of protein quality. This investigation is being conducted under a grant with Iowa State University at Ames. The spleen, important in the production of antibodies, decreased in weight and in number of cells when rats were fed a protein deficient diet. The reduction in antibody formation appeared to be due chiefly to a decrease in the number of cells capable of synthesizing antibody protein rather than to a reduction in the capacity of individual cells to produce antibodies. These results were reported at the meeting of the Federation of American Societies for Experimental Biology in April 1967.

4. Aging processes in relation to dietary protein. A project has been initiated to investigate the influence of level of dietary protein and heredity on body composition, aging processes, and longevity. This project will be carried out under a research grant with Red Acres Farm, Inc. at Stow, Massachusetts. It will provide information on protein needs in relation to age and determine whether or not there are potential problems from excessive protein intake by an aging population. The extent to which heredity may be a factor in response to level of protein will be determined and should aid in understanding the variations in protein requirements of individuals.

5. Minerals. Research has been initiated to determine the changes that occur in calcium metabolism with age and the effect of dietary calcium intake on these changes. This investigation will be carried out under a research grant with the University of Louisville at Louisville, Kentucky. The factors to be investigated include calcium intake, calcium absorption, exchange between body pools, bone deposition, and urinary and fecal excretion. Information on adaptation of calcium metabolism to level of intake and the changes that occur with age should provide a sounder basis for predicting calcium needs throughout life than is currently available.

C. Tables of Food Composition

1. B-vitamins in foods. Summarization of data and derivation of representative values for a publication on the content of pantothenic acid, vitamin B6 and vitamin B12 are now complete for some 700 items of food. The values will provide the basis for evaluating food supplies and diets with respect to these vitamins.

2. Nutritive value of retail and household units of food. The development for publication of a table showing nutritive values of foods in terms of common retail and household units is continuing. Values will be given for proximate composition, calcium, phosphorus, iron, sodium, potassium, vitamin A, thiamine, riboflavin, niacin, ascorbic acid, and selected fatty acids. Final values are now ready for more than 500 items of food and are nearing completion for many others.

3. Revision of Handbook No. 8. Work to obtain data for the next revision of Agriculture Handbook No. 8, "Composition of Foods...Raw, Processed, Prepared," is proceeding along several lines.

A study of the relationship among nutrients in milk and selected cheeses has been initiated to obtain needed data on the composition of these foods (see A-7). Information from this new study should serve as a basis for evaluating scattered data in the literature, and for developing values suitable for inclusion in tables of food composition.

Methods for calculating nutritive values of cooked pork, lamb, and fish from raw cuts of meat and fish are under study. A study of the literature on thiamine and riboflavin contents of raw and cooked beef to obtain data for reappraisal of vitamin retention values is nearing completion.

A search of the literature has shown that poultry is among several foods for which few data are available for sodium and potassium. Possible arrangements for obtaining such data are being explored. A source of extensive data on trace elements in foods has been located and tentative arrangements have been made for obtaining the data.

D. Food Consumption and Diet Appraisal

1. 1965 nationwide survey. Analysis of the household data showed that families surveyed in the spring of 1965 spent 36 cents of their food dollar for meat, poultry, fish and eggs; 19 cents for vegetables and fruits, including juices; 13 cents for milk and milk products; 12 cents for flour, cereals, and bakery products; 10 cents for beverages other than milk and juice; and 10 cents for fats, sweets and all other foods. This division of the food dollar varied little among groups of families whether classified by region, urbanization or income. Choices within these broad groups did vary. For example, farm families used more flour, fat, sugar, and eggs per person and less bakery products than city families. Southern families used the most pork, poultry, and fish and the least beef; western families used the most beef.

Families surveyed in the spring of 1965 used more beef and poultry and less pork, fish and eggs than families surveyed in the spring of 1955. The families surveyed in 1965 also used more frozen milk desserts, cheese, dry and fresh skim milk and less fresh whole milk, cream, and evaporated milk; more canned and frozen vegetables and fruits and less fresh vegetables and fruits; more breakfast cereals and bakery products other than bread and less flour, bread and cereals other than breakfast cereals; more margarine and oils and less

butter and shortening. Many of the changes reflected the trend to increased use of commercially prepared foods. There was also greater use in 1965 of food associated with snacking--ades and punches, soft drinks, potato chips, luncheon meat, peanut butter, crackers, cookies, doughnuts and candy.

Papers reporting findings on the food consumption of households in spring 1965 were presented at three National meetings. One preliminary report was published and a second was prepared for publication. Final reports are in preparation--one for the U.S. as a whole and one for each of the four census regions. These reports will provide information on the percentage of families using major groups, subgroups, and selected items of foods as well as the quantities and money value of the foods consumed. This information will be given separately for urban, rural nonfarm, and rural farm families and for all urbanizations combined. Another classification will be by income of family.

2. 1967 survey in two counties in Mississippi. In May 1967, a survey was made to evaluate two types of food distribution programs in two counties in the Mississippi Delta. The survey was made by the Consumer and Food Economics Research Division, ARS, in cooperation with the Economic Research Service. In Washington County, a Food Stamp Program had replaced a Food Donation Program in March 1967. In Sunflower County, a Food Donation Program of long standing was in operation. The families surveyed included participants and eligible nonparticipants in both the Food Stamp Program and the Food Donation Program.

Preliminary evaluation of the data indicated that the average diet was poor. Foods most needed to improve the diets of these families are milk products, vegetables and fruits. Diets of families who participated in the food program were similar in many respects to those who were eligible but did not participate.

Money value of the food used averaged about \$4.00 a person a week (including value of free food stamps and donated commodities). This is about 25 percent less than the cost of the USDA Low-cost Food Plan for the South. On the average the families included in the survey spend about one-half of their incomes on food.

Data on height and weight were obtained as an indication of the growth and nutritional status of children 2 to 12 years old in the families surveyed and are being evaluated by the Human Nutrition Research Division.

3. Preschool children in Hawaii. Data needed to assess the nutritional situation of children 2 to 3 years of age in low-income families and middle-income families in Honolulu have been collected. Included are a 3-day record of the child's food intake, a physical examination record, and information on the child's early diet, on the mother's food practices and attitudes, and on the family's socioeconomic situation. Data collected in biochemical, clinical, and psychomotor tests are being evaluated. The research is being carried out by the University of Hawaii under cooperative agreement with the Consumer and Food Economics and the Human Nutrition Research Divisions.

4. Nutritive value of the national food supply. Food energy (calories) and selected nutrients provided by the per capita food supply are estimated each year by the Consumer and Food Economics Research Division from data on apparent civilian consumption, retail basis, developed by the Economic Research Service. The estimates show that shifts in food consumption over the years have resulted in changes in the sources of fat, carbohydrate and protein. Vegetable fat now accounts for a higher percentage of total fat because of the shift from butter to margarine and from lard to shortening and the sharp increase in use of salad and cooking oils. The share of calories derived from total nutrient fat which increased from 1909 to the early 50's has changed little since. Saturated fatty acids account for a smaller share of the total fat today than they did 55 years ago--37 percent compared with 40 percent--even though the American diet now contains more fat. Oleic acid continues to account for about 41 percent of the total fat. The share attributed to linoleic acid has been increasing and is now roughly 13 percent. Animal products contribute two-thirds of the protein today compared to one-half 55 years ago. Starch and sugars now contribute about equally to total carbohydrates; in 1909-13, two-thirds was provided by starch and one-third by sugars.

5. Nutrient content of school lunches. A nationwide study of the nutrient content of Type A lunches served to 6th graders is being carried out by the Consumer and Food Economics Research Division in cooperation with the School Lunch Division, Consumer and Marketing Service. The study was undertaken to obtain data needed for evaluating the Type A pattern. Twenty lunch composites from each of 300 schools in 19 states in 5 geographic regions have been analysed by a contractor, the Wisconsin Research Alumni Foundation, for proximate composition, fatty acids, and 12 minerals. Analyses are in progress for seven vitamins, iron and residues of chlorinated hydrocarbon insecticides.

In general, the lunches met the nutritional goal of one-third of the 1963 NRC Recommended Daily Dietary Allowance for 9 to 12 year olds for energy, calcium and protein. The average energy level of the lunches from the 300 schools was 735 Calories--the goal for girls and a little under the goal of 800 Calories for boys. On the average, 39 percent of the calories were provided by fat in the lunches. The average calcium content was 400 milligrams per lunch--a little more than the goal of 367 milligrams. For protein, all lunches met the goal of one-third of the Recommended Daily Allowance for 9 to 12 year olds--18.3 grams for girls and 20 grams for boys.

6. Acceptance of Type A lunches. A study of factors affecting acceptance of the lunch program by 10th grade students in Louisiana is being carried out under cooperative agreement with Louisiana State University. Thirty students from each of 17 schools, their parents and the officials of the schools provided information for the study. Included were urban and rural schools, large and small schools, and schools with low, medium and high levels of participation in the lunch program.

E. Support for Food and Nutrition Programs

1. The fifth national Nutrition Education Conference was held in Washington, D.C., February 20-22, 1967, with about 275 persons representing a wide variety of agencies and disciplines from most of the states. The theme was "effective communication" and coordination of nutrition programs as a means of facilitating behavioral changes in eating habits. The Conference was cosponsored by the Consumer and Food Economics Research Division and the Interagency Committee on Nutrition Education.
2. Bimonthly publication of Nutrition Program News, which reaches some 7,000 workers in nutrition and related fields was continued.
3. Technical assistance to programs. Nutrition research findings continue to be studied and interpreted for application to problems in food selection and food use. Technical assistance was given by nutritionists to programs of other government agencies such as the food and nutrition programs of Project Head Start, Office of Economic Opportunity. Talks to groups involved in community nutrition programs, radio and TV tapes on nutrition, and consultant help and participation in conferences contributed to coordination and strengthening of nutrition programs.
4. Food for low-income families. Recipe development is continuing for commodities that are distributed to low-income families participating in the USDA food distribution program or the Food Stamp Program. These supplement the series of 17 commodity leaflets now available for national distribution as part of the Department's participation in the Federal program to combat poverty. This work by the Human Nutrition Research Division is in cooperation with the Consumer and Marketing Service. Negotiations were completed with the University of Maryland to have USDA recipes tried and evaluated by low-income families living in housing developments in Washington, D.C.
5. National school lunch program. Research on quantity food preparation and food quality in the Human Nutrition Research Division has provided help to school lunch managers across the nation to make the best use of donated food commodities available to them and other foods obtained on the local market. "Favorite" recipes from schools were standardized and published for other schools to try. A survey of pupil acceptance of these recipes in about 100 schools in five areas of the United States is in progress.
6. Project Head Start--food buying guide and recipes. A 130-page manual prepared by the Human Nutrition Research Division for the Head Start Program of the Office of Economic Opportunity gives quantity recipes and food buying guides needed to prepare nutritionally adequate meals for groups of 25, 50, or more preschool children from low-income families. Food served in Head Start Centers must be inexpensive to buy, easy to prepare with limited kitchen equipment, and attractive and appealing to small children.
7. Guides for consumers. Three new consumer publications on animal products are in press or recently published: "Beef and Veal in Family Meals," "Lamb in Family Meals," and "Milk in Family Meals."

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DAIRY UTILIZATION - FOOD
Eastern Utilization Research and Development Division, ARS

Problem. Utilization research on milk is conducted in order that the milk products industry can defend and expand its markets by (1) developing new and improved products and (2) by developing new and more efficient processing techniques.

The importance of this research can be gauged from the vast size of the industry, for dairying is one of the largest segments of American agriculture, milk is the base of an enormous processing and distributing systems, and milk is nutritionally important:

Farm cash receipts from milk and cream marketings provide more than five billion dollars a year, about 13% of all cash receipts from farm products; only livestock marketings are greater.

The retail value of milk and milk products is eleven billion dollars a year.

Milk production is over sixty million tons a year; dairying is first in farm income in 9 states, second in 6, third in 7 and important in all the rest.

The farmer's share of the consumer's food dollar spent on dairy products averages 44 cents whereas the average share for all foods is about 38 cents.

Milk contributes about a quarter of the protein in the American diet and most of the calcium, phosphorus and vitamin B₂.

Per capita consumption of milk in the United States has been decreasing steadily and is now about 579 pounds per year, well below that of many foreign nations, including Finland, Ireland, New Zealand, Canada, Australia, Sweden, Denmark, Norway, Switzerland, Belgium and the United Kingdom, all of which consume more than 800 pounds per capita. It is thus evident that there is opportunity to increase milk consumption, despite the tremendous variety of ways in which our populace can spend its money, and the freedom it has in deciding what or what not to buy.

Milk is a biological secretion and a valuable human food, but basically it is a complex mixture of complex chemical substances. Finding out what these substances are, what their individual properties are, how to speed up, slow down, direct and, in sum, control their reactions is vital to practical development of new markets based on new products or processes, improvement in existing products processes, or cost reduction in existing processes.

The lead time to such development may be several years. This kind of research is recognized as a province of government laboratories, state and national,

since it is basic to the whole milk industry and the results are freely available to all. Outside public research, such studies could be undertaken only by the very largest industrial laboratories and these would, quite understandably, disseminate results only as they saw fit and doubtless for their own profitability.

Government properly sponsors only research and development that the milk industry can not be expected to do for itself: projects of long duration requiring larger resources, having a substantially greater element of risk or, as with basic research, lacking the prospect of full private exploitation.

Government research and development on processes and products normally proceeds to such a technical stage that industry can logically decide whether or not to adopt them and, when adopted, government may properly also provide technical advice during the first stages of commercial application.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving chemists, biochemists, microbiologists, food technologists and engineers engaged in basic research on the composition and properties of milk and in applied research directed to the development of new and improved dairy products and processing technology. The Department's research facilities are located in Wyndmoor, Pa., Washington, D. C., and Beltsville, Md. In addition, some Division research work is conducted at Brandeis University, Waltham, Mass.

The Federal (USDA) scientific effort devoted to research on milk totals 61.9 scientist man-years which includes 6.6 scientist man-years in the domestic contract and grant research program. This effort is distributed as follows:

(a) Chemical Composition and Physical Properties. Research at Wyndmoor, Washington, and Waltham, totals 25.9 scientist man-years, devoted to properties of protein complexes in milk, properties of the various caseins in milk, the interaction of milk proteins in solution, composition and structure of protein components of milk, the behavior of milk enzymes, and study of ribosomal nucleic acids.

Contract research at the University of Maryland, College Park, (0.5 scientist man-year) deals with the relation of milk fat composition to the diet of the cow. Contract research at the University of Minnesota, St. Paul, (0.5 scientist man-year) is concerned with the possible role of genetics in affecting the heat stability of individual milks. Contract research at Ohio State University, Columbus, (0.6 scientist man-year) deals with the calcium phosphate complex in milk and milk concentrates. In addition, research sponsored by the Department under PL-480 grants is in progress at the following foreign institutions:

1. Indian Institute of Science, Bangalore, India, on phosphoproteins of milk (5 years, 1963-1968).
2. National Dairy Research Institute, Karnal, Punjab, India, on the proteose-peptone fraction of milk (5 years, 1963-1968).
3. Israel Institute of Technology, Haifa, on the formation of unnatural nucleic acids (3 years, 1965-1968).
4. University of Uppsala, Uppsala, Sweden, on the development of methods for purification of milk proteins and studies of their structure (5 years, 1963-1968).
5. College of Agriculture in Olsztyn, Poland, on mechanisms of the cheese-ripening process (5 years, 1963-1968).
6. University of Graz, Graz, Austria, on the structures and interactions of nucleic acids by means of small angle X-ray studies (5 years, 1966-1971).

During the year, research under PL-480 grants was completed at (a) Institut National de la Recherche Agronomique, Paris, France, on the non-protein nitrogenous substances formed from milk proteins during industrial treatments, (b) Centre de Recherches sur les Macromolecular, Strasbourg, France, on the subunit structure of nucleic acids, and (c) Instituto Nacional de Tecnologia, Rio de Janeiro, Brazil, on the structure and properties of proteolytic enzymes.

(b) Flavor. Research at Washington involves 9.9 scientist man-years devoted to the study of stale flavor and flavor stability in sterile milks. In addition, grant research at the University of Maryland (0.5 scientist man-year) is devoted to milk flavors and flavor precursors that are derived from pasture or dry feeding practices. Grant research at Oregon State University, Corvallis, (1.0 scientist man-year) is directed to isolation and identification of specific flavor contributing compounds in butter. Grant research at the Pennsylvania State University, University Park, (0.9 scientist man-year) is devoted to study of the origin and control of lactones, methyl ketones and their precursors in milk as a basis for the development of procedures to avoid the undesirable flavor effects of these substances in milk products.

In addition, research sponsored by the Department under PL-480 grants is in progress at the following foreign institutions:

1. National Dairy Research Institute, Karnal, Punjab, India on sulfur compounds in milk

and milk products and their relation to cooked flavors and oxidative stability (5 years, 1963-1968).

2. Biochemical Institute, Helsinki, Finland, on dietary factors controlling flavor in milk (5 years, 1964-1969).

(c) Color, Texture and Other Quality Factors. Research at Washington totals 3.0 scientist man-years devoted to investigation of the allergens of cow's milk and of the physical stability of sterilized milk. Contract research equivalent to 1.5 scientist man-years is in progress at the Pet Milk Company, Greenville, Illinois, to study the stability of commercial fluid milk during refrigerated storage over periods great enough to permit the radioactivity of iodine-131 to decay to harmless levels.

Research was initiated under a PL-480 grant at Hebrew University, Hadassah Medical School, Jerusalem, Israel, to study the immunological reaction of infants to cow's milk (3 years, 1966-1969).

(d) Microbiology and Toxicology. Research at Washington involves 1.0 scientist man-years devoted to study of the chemical and physical mechanism of the development and maintenance of heat resistance and dormancy in bacterial spores. Contract research at the University of Wisconsin, Madison, (0.1 scientist man-year) concerned with the effects of nonfat dry milk on bread yeast fermentation was completed. In addition, research under a PL-480 grant is in progress at the U. P. Agricultural University, Pantnagar, India, on factors which influence the synthesis of dipicolinic acid in bacterial spores (5 years, 1966-1971).

(e) Technology - Process and Product Development. Research on process and product development totals 15.5 scientist man-years at Washington, Wyndmoor and Beltsville, on the preparation of dry whole milk by the vacuum foam-drying process (Wyndmoor), the foam spray-drying process (Washington), the development of improved dairy processing equipment, new product development based on butter fat, and investigation of survival of Salmonella during cheese manufacture. Grant research at North Carolina State University, Raleigh (0.7 scientist man-year) deals with physical changes in milks due to steam injection. Heat transfer in powdered milk will be studied under a grant at Michigan State University, East Lansing, (0.3 scientist man-year). Contract re-research on removal of radionuclides from milk by fixed- and moving-resin-bed systems was completed.

Additional research sponsored by the Department under PL-480 grants is in progress at the following institutions:

1. National Dairy Research Institute, Karnal, Punjab, India, on the isolation and use of milk coagulating enzymes for cheese manufacture (5 years, 1962-1967).

2. National Dairy Research Institute, Karnal, Punjab, India, on the role of starter bacteria and some genetic variants in the development of flavor during the manufacture of cheese (5 years, 1966-1971).
3. "Juan de la Cierva" Foundation for Applied Research, Madrid, Spain, on the thermal and related physical properties of milk and milk products (5 years, 1964-1969).
4. Technical University Berlin, Berlin, West Germany, on chemical changes at the surface of fat globules in foam-dried whole milk (4 years, 1963-1967).

During the year, research at Kaira District Cooperative Milk Producers Union, Ltd., Anand, India, was completed on the addition of nonfat dry milk solids to buffalo milk in the manufacture of hard cheese.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 67.6 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

In normal β -lactoglobulin polypeptide linear zigzag and α -helical forms predominate. The zigzag or pleated sheet structure is concentrated near the molecule surface. Controlled changes in the proportion of ordered versus disordered parts of the molecule and in the type of order can be produced by altering the solvent. α_{s1} -casein B, the most frequently occurring genetic variant of the calcium-sensitive casein of cow's milk, has a molecular weight of 24,600 in 3 M guanidine hydrochloride at pH 7 as determined by sedimentation equilibrium. In glycine-NaOH buffer (pH 12, $I^- = 0.5$, 25°) it degrades slowly and irreversibly and after one week molecular weight is 14,000. For the three major caseins of cow's milk, α_{s1} , β and κ , a very low α -helix content and a low degree of structural organization is evident. However, appreciable α -helix formation can be produced by dissolving the casein in a solvent such as 2-chloroethanol or acidic methanol.

Stable bacterial ribosomal nucleic acid (H-RNA) was prepared by carefully freeing the material from traces of ribonuclease. Molecular weight measurements at ionic strength of 0.15 and 0.01 confirmed that this H-RNA is a mixture of two components with molecular weights of 1,000,000 and 500,000. Degradation experiments indicate that either ribosomal RNA is a closed loop or has cross-links between segments of the polynucleotide chains. Hence, the usually accepted structure of a long random chain (mostly single stranded) must be rejected.

In research at the Israel Institute of Technology, Haifa, the formation of "unnatural" nucleic acids was studied in two bacterial systems, one infected by virus particles (T4). Upon infection of a bacterial cell by a virus, the only new ribonucleic acid (RNA) formed is messenger RNA.

The work on the isolation and characterization of acid ribonuclease, acid phosphomonoesterase and exonuclease, conducted at the Centre de Recherches sur les Macromolécules, Strasbourg, France, was completed. The methods of preparation were derived from that devised for acid DNase. The preparation of these enzymes is significant because, (1) the enzymes were obtained as highly purified preparations during the chromatographic purification of acid DNase; (2) acid phosphomonoesterase and spleen exonuclease were essential for determining the specificity of acid DNase, (3) acid RNase, acid phosphomonoesterase and acid DNase are the first enzymes from lysosomes prepared in a homogeneous state.

The terminal oligonucleotides obtained by digesting DNA with acid DNase were studied in detail. Their average size was equal to 10 residues 30-35% of the digest being tetra- to octanucleotides. The remaining 65-70% were larger oligonucleotides.

At the University of Graz, Graz, Austria, research is continuing on the study of the structures of nucleic acids by means of small angle X-rays. By plotting the cross-section factor, pure DNA produced the expected radius of gyration ($R = 8.4\text{\AA}$) and the known mass per unit length. The addition of actinomycin effected an increase in intensity at small angles. This is explained as a cross-linking effect.

In research cooperative with EU, Dr. John Gregory of Rockefeller University found that one molecule of milk ribonuclease B contains one molecule of galactosamine and apparently 2.6 molecules of glucosamine confirming EU results obtained by less elegant methods. Whether the fractional number of glucosamines is due to imprecision of method or accurately indicates the average content of an inhomogeneous protein is not known. The acetyl-, propionyl-, isobutyryl-, and butyryl-derivatives of β -casein A' have been prepared by reaction of the acid anhydride in a dimethylsulfoxide solution. At least 90% of the ninhydrin-positive material in the protein is lost, indicating that the amino groups are acylated to this degree. Dimethylsulfoxide is a particularly good solvent for acylating the caseins for both casein and acid anhydrides are soluble in this reagent.

In enzyme research at EU, milk ribonuclease B and pancreatic ribonuclease B were separated by column chromatography, thus confirming differences observed earlier for carbohydrate composition.

κ -Casein (κ -casein) preparations from individual cow milks show either one or two major components (probably genetic variants) and several minor components all part of the κ -casein complex as judged by ability to stabilize α_s -casein and to be acted on by rennin. In this research at EU it was found that the action of rennin leads to formation of homogeneous carbohydrate-free

p(para)- κ -casein and macropeptides, some of which contain carbohydrate. The insoluble p- κ -casein may be coupled to bovine serum albumin to prepare soluble derivatives. These derivatives can form stable complexes with α_{s1} -casein in the presence of calcium ion, suggesting that the association between α_{s1} -casein and κ -casein is a property of the p- κ -portion of the molecule. The inability of κ -casein to stabilize α_s -casein when photooxidized suggests that the site of association may involve histidine and perhaps tryptophan of κ -casein. When the calcium sensitive components of α_s - and β -caseins were modified by reaction with formaldehyde or cyanate ion, the calcium-binding capacity of these proteins was not changed but the modified proteins no longer precipitated in the presence of calcium ion. Furthermore, κ -casein similarly modified by a formaldehyde or cyanate ion no longer stabilized α_s -casein toward calcium ion. Amino acid analysis indicates that lysine residues are implicated. Crystalline polymorphs of β -lactoglobulin have been treated with sodium dodecyl sulfate-S35 and the derivatives were crystallized and analyzed by scintillation counting methods. All contained 2 moles of bound dodecyl sulfate per mole of protein.

Adsorbents capable of selectively binding particular proteins are being developed at the University of Uppsala, Uppsala, Sweden.

At the Pioneering Research Laboratory for Physical Biochemistry, Waltham, Mass., research is continuing on (a) interactions between proteins and solvent components and (b) conformational changes in β -lactoglobulin. It has been found that chloroethanol (strong structure former) is bound preferentially to β -lactoglobulin below 40% (v/v in water), whereas above this concentration water is bound preferentially.

Contract research at the University of Minnesota with 3:1 concentrated skim milk demonstrated no consistent difference in the pH-heat stability of milks containing κ -casein A and κ -casein B. Thus, variations in heat stability of milks have not correlated with α_s , β , or κ -casein types. The heat stability of mixtures of pairs of individual milk samples from casein-typed cows was not necessarily the mean of the two individual samples even though dialysis supposedly eliminated salt effects. Evidently there are complex interactions here that are not understood.

In research conducted at Wyndmoor, amino acid analysis of a newly isolated β -casein polymorph designated A³ was found to contain 4 residues of histidine per molecule compared with 6 in β -casein A¹, 5 in A², and 6 in β -caseins B and C. A second β -casein polymorph, designated D, was prepared from the milk of a zebu cow. It differs in content of lysine, histidine, arginine and alanine from β -casein B of the zebu cow. "Difference peptides" from α_{s1} -caseins B and C were isolated; the extra glycine residue which distinguishes α_{s1} -casein C from B is found in the difference peptide of C while the extra glutamic acid residue characteristic of α_{s1} -casein B is in the difference peptide of B. The two peptides are otherwise identical. γ -Casein occurs in at least two different forms, designated A and B, as shown by disc gel electrophoresis. The polymorphism is probably genetically controlled.

In comparative studies of β -casein from cow and buffalo milk, it has been found that, as in cow milk, polymorphism of this component of casein occurs in buffalo milk as well. An apparatus was devised for electrophoretic separation of the polymorphs on acrylamide gel. This research is in progress at Indian Institute of Science, Bangalore, India.

Basic research on the mechanisms of the cheese-ripening process was continued at the College of Agriculture in Olsztyn, Poland. Most attention was given to the identification and characterization of products formed on the decomposition of casein by rennin. These include peptides, amino acids and other degradation products. Model systems were used to study extracellular protease of Streptococcus lactis which is actively proteolytic. Rennin split off glycopeptide from κ -casein causing coagulation. It also continued an active proteolytic role during cheese ripening.

Electron microscope studies at EU on the size distribution of casein micelles showed a slight increase in micelle size with decrease in temperature from 26°C. to 0°. Centrifuged skim milk showed no separation of micelles by size. The casein micelles of a 3:1 sterilized skim milk concentrate and a similar concentration with added polyphosphate, examined weekly for four months by electron microscope techniques showed no difference in micelles between milks with and without polyphosphate although gelation occurred in the control sample. The micelles of the concentrated milks were about 2- to 2-½ times as large as micelles from fresh single strength skim milk. In grant research at Ohio State University, Columbus, the nuclear magnetic resonance studies of pure casein components and salt solutions was extended to milk systems, and electron microscope studies of the micelles in the milk samples undergoing nuclear magnetic resonance studies have also been initiated.

In PL-480 sponsored research at the National Dairy Research Institute, Punjab, India, the composition and size of the proteose-peptone fraction of cow and buffalo milk was found to be influenced by genetic makeup of the milk producer, stage of lactation and heat treatment. Paper electrophoresis, gel filtration and a new colorimetric procedure developed on this project were used to study the observed variance in the proteose-peptone fractions. These methods were also used to follow the changes in the proteose-peptone fraction of milk exposed to the action of rennet. A further study of the proteose-peptones in various dairy products showed measurable differences between these fractions in evaporated milks made in India and the United States.

Contract research at the Maryland Agricultural Experiment Station showed that cows receiving corn silage as their only forage produced slightly more milk than those receiving both hay and corn, and their milk was higher in fat, protein and solids-not-fat. The stage of lactation appears to have some effect on fatty acid composition. In early lactation the percent of oleic acid was unusually high and palmitic acid unusually low compared with late lactation. These changes appear to be due to a more rapid decrease in oleic acid than to total fatty acid content at later stages of lactation.

Differential thermal analysis (DTA) and calorimetry are now being used in a study at EU of properties of milk fat. Heats of melting and specific heats of milk fat and DTA studies on the crystallization behavior of a hydrogenated milk fat have been carried out.

The volatile carbonyl and hydroxy compounds in normal and in "zero" milk fat were determined. Zero milk is obtained from cows on a purified, protein-free diet. It is thus free from flavor substances possibly carried over from conventional feeds. The results of the determinations are as follows: (a) an array of volatile carbonyl compounds exist in both fats; (b) a new class of carbonyl compounds exists in both milk fats; (c) both normal and zero milk fat contain the C₃, C₄, C₅, C₆, C₇, C₉, C₁₁ and C₁₃ methyl ketones although some of these may be generated during distillation; (d) both normal and zero milk fat contain a series of saturated aldehydes from C₃ through about C₁₄; (e) both normal and zero milk fat contains a series of 2-enals from C₅ through about C₁₂; neither milk fat contains any detectable 2,4-dienal. (Cooperative with Professor A. Virtanen, Biochemical Institute, Helsinki, Finland).

B. Flavor

Sterile fluid milks containing added kynurenine and tryptophan were prepared; after three months' storage at 80°F. no significant flavor difference between the supplemented and control samples were observed. The O-aminoacetophenone believed to be a major contributor to the off-flavors appears to be associated with the whey proteins. The observation that steam deodorization of butteroil yields a butteroil product stable for more than a year when stored under nitrogen at 80°F. but that sterile milks prepared with steam deodorized butteroil developed a stale flavor, suggests that the skim milk portion of the milk is a major contributor to the stale flavor in sterile milk.

A number of aromatic compounds have been identified by the application of gas chromatographic and mass spectrometric techniques to the volatiles obtained from low temperature steam distillation or steam stripping of cream butter serum and butteroil in grant research at Oregon State University. The origin of these compounds is unknown, but literature reports suggest that they may originate in animal feeds. Preliminary taste panel studies suggest that certain lactones, methyl ketones, fatty acids, aldehydes and dimethylsulfoxide contribute significantly to the flavor of butter. Grant research at the Pennsylvania State University indicated that metabolic disturbances such as ketosis and parturition dramatically decreased the concentration of lactone potential of milk fat. A pronounced seasonal trend was observed, lactone concentration being higher in winter than in summer milk. Since it was established earlier that feeding practice can affect lactone potential, it seems clear that lactone precursors are apparently by-products or end-products of endogenous metabolism.

During the year research at the National Dairy Research Institute, Punjab, India, under a PL-480 grant showed that the sulphydryl content of both buffalo and cow's milk varied seasonally, being high in September and February and low in May. This may reflect stage of lactation and feed of the producers since

both were found to influence the sulfhydryl content of milk. When cow's milk was stored at 0 - 4°C. sulfhydryl content dropped more rapidly in buffalo milk. Preliminary results indicate sulfhydryl compounds in milk activate alkaline phosphatase and may reactivate the enzyme activity lost during heat treatment. Work on the isolation and characterization of the low molecular weight sulfhydryl containing compounds in heated milk has been initiated.

The study of dietary factors controlling flavor in milk is continuing under a PL-480 grant at the Biochemical Institute, Helsinki, Finland.

Milk production of test animals maintained on a protein-free diet continues to increase and an annual yield of 9000 pounds of milk has been achieved. Analysis of the various constituents of milk continue to emphasize the close similarity between test and normal milk.

Grant research at the University of Maryland demonstrated that supplementing a basic ration of alfalfa hay and grain with α -tocopherol acetate eliminated the susceptibility of milk to the development of oxidized flavor both spontaneously and under induction by 0.1 ppm copper. Under normal conditions one gram per cow per day is sufficient. Analysis of the natural α -tocopherol content of various forages indicates that the growth stage and preservation methods are important factors governing the amount of natural α -tocopherol available to the cow.

Research at EU showed that heating milk fat in the presence of nonfat milk solids definitely enhanced its flavor and flavor stability. Heated milk fat, liquid and solid fractions made from it, and vegetable fat were used to make caramels. After six months the flavor of those made with the liquid fraction of heated milk fat was best. A liquid fraction from heated milk fat improved the flavor of commercially manufactured butter cream candy. The solid fraction increased consistency. Heated milk fat also enhanced the flavor of ice milk.

Determination of the peroxide values of the off-flavored foam-spray dried whole milk powders produced during the summer months failed to show that oxidative changes during drying were responsible for flavor deterioration. This correlated well with a later finding suggesting that the summer flavor developed during drying even though the air in the vicinity of the dryer was very low in ozone. The equipment has now been installed to permit the direct collection of volatiles in the atmosphere entering the Dairy Products Laboratory spray dryer. The micro-particles will be collected and analysis made by nuclear activation techniques.

C. Color, Texture and Other Quality Factors

Progress is being made in control of sedimentation which occurs in high-temperature short-time (HTST) sterilized milk products. Sterilizing before concentration reduces sedimentation of denatured proteins. The addition of hexametaphosphate and orthophosphate to milks before sterilization also reduces the amount of sedimentation in milks sterilized both before and

after concentration.

Quantitative determination of tryptophan in milk proteins were continued to study the relation of tryptophan content to antigenic properties. Two basically different methods of analyzing for tryptophan gave good agreement on 31 proteins including the A, B and C variants of β -lactoglobulin, α_s - and β -casein, the A and B variants of κ -casein and α -lactalbumin. No difference was found in tryptophan content of any of the variants.

κ -Casein was found to have one tryptophan residue per mole in contrast to two reported in the literature.

Pepsin digests of β -lactoglobulin were used to prepare rabbit antisera to test for possible development of new antigenic specificity. Antibodies for β -lactoglobulin were found in hydrolyzates up to and including the 15-hour digests.

From a group of 24 individuals who gave positive allergic reactions to skim milk by direct skin tests, 7 individuals provided sera which induced high sensitivity to skim milk in passive transfer sites in the allergic groups. Sensitivity was directed most strongly to α -lactalbumin and β -lactoglobulin.

In a study to develop improved assay methods rabbits were sensitized to crystalline ovalbumin via the footpads and subsequently challenged, severe shock occurred 10-14 days after the sensitization. However, assay for passive cutaneous anaphylactic antibody in the sera did not correlate well with the systemic reactions. The poor correlation between the titer of the antiserum and the appearance of systemic symptoms suggests that different antibody systems may be involved in these two phenomena.

D. Microbiology and Toxicology

1. Microbial spores. Preliminary experiments with a microwave generator suggests that frequencies near 22,000 mc per second may be lethal for microbial spores. However, reproducibility of these results has not been satisfactory partly because of assay method limitations and partly because of the low maximum power output which is available. The lethal effect is envisioned as occurring through denaturation of vital specific spore structures which would resonate with certain microwave frequencies producing micro-heating within the spores.

Results of research on techniques of controlling spore germination indicate that reduction of disulfide groups in the spore coat is involved in the germination process.

In research at the National Dairy Research Institute, Karnal, Punjab, India, various synthetic liquid media were tested for obtaining rapid growth and sporulation of a strain of Bacillus subtilis. A medium in which 93% (by staining) of the cells sporulated was developed and adopted for further studies. Maximum sporulation was obtained 33 hours after transfer into the

final culture flask and the total maximum growth obtained was 2.0×10^8 cells/ml. Presence of sodium citrate was found to be essential for sporulation and this requirement could not be replaced by malate or sodium acetate. It is planned to use this medium for the studies of factors which influence the process of sporulation and heat resistance of spores.

2. Bread yeast activity. Contract research at the University of Wisconsin on the effects of nonfat dry milk on bread yeast has been completed. This work has shown that continuously produced yeast ferments which incorporate nonfat dry milk are as good as batch ferments for use in continuous baking. Yeast activity was increased by the addition of up to 4% of nonfat dry milk to the yeast food. A process employing a 30-liter continuous fermentor saves operational time, permits accurate control of the sugar level and pH during fermentation and yields a uniform and accurate yeast brew. The data on stimulation of yeast activity by nonfat dry milk, providing improvement of bread quality, should lead to increased use of nonfat dry milk by the baking industry and help to overcome problems that had been encountered in the early development of continuous breadmaking processes.

E. Technology - Process and Product Development

1. Dried milk. A dried nonfat milk with good dispersibility and sinking properties was prepared by the incorporation of either carbon dioxide or nitrogen into the dryer feed at the rate of 0.05 to 0.07 cubic feet of gas per 10 pounds of concentrate. Addition of 0.05 cubic feet of either gas into a dryer feed containing only the liquid fraction of milk fat in such quantities as to give a 1% fat containing beverage on reconstitution yielded a fat-containing milk powder with good dispersibility and sinkability. Previous work has shown that expert tasters have difficulty perceiving significant flavor differences between reconstituted milk containing from 1 to 4% butterfat especially when the nonfat solids of the low-fat milk is raised to compensate for the lower fat value.

Progress was made in the study of the compounds responsible for the fat-derived stale flavor of whole milk powder. Butteroil stored in an inert atmosphere was subjected to a low pressure steam distillation; at 50°C. and 1 mm. pressure the off-flavors could be removed completely from stale butteroil. Gas-liquid chromatography indicated at least 40 volatile compounds in the distillate. Eleven compounds accounted for the bulk of the volatile material. The taste panel applied "stale" and "unclean" criticisms to the more volatile fractions.

The methods developed by Dr. D. P. Schwartz, of the Dairy Products Laboratory (DPL) have been used in PL-480 sponsored research at Technical University, Berlin, West Germany, to study the carbonyls in fresh butterfat and samples of spray-dried milk powder stored under various conditions. Significant change in the carbonyl fraction during the storage of whole milk powder only occurs if the product is exposed to air during storage. Under these conditions a marked increase in ketone content is noted. These findings tend to indicate that the development of "stale" flavor in DPL-developed whole

milk powder during storage is probably not associated with marked changes in its carbonyl content.

In research at EU, a recording microbalance has permitted precise determination of the adsorption-desorption isotherms for water vapor on spray-dried and foam-spray-dried whole milk, skim milk and whey powders. Sample is 10 mg. The results demonstrate that conventionally spray-dried powders are not more hygroscopic than comparable foam-spray-dried materials. Powders held in water vapor containing atmospheres and then redried undergo distinct structural changes in the powder particles, affecting the porosity of the powders. These findings were made by gas diffusion techniques. The immersion of dried milk powders in ammonium sulfate solutions results in the leaching out of lactose and salts of milk while the particles retain their structure. More than 80% of the total calcium may be removed from foam-spray-dried skim milk powders. The skeletal structure which remains after removal of calcium lactose from milk powders constitutes evidence for some sort of protein-protein interaction which occurs during the dehydration step.

The best available mathematical model describing the continuous vacuum foam drying process was used to predict conditions necessary for year-round operation of the vacuum foam dryer at economical rates. On the milks available (winter and spring transitional) there was good agreement between the predicted and observed results. At the end of their research phase under this project the results, some of which were reported earlier, are as follows:

There has been produced in the pilot plant by a continuous process a product which reconstitutes with (a) good flavor, texture and appearance, (b) excellent cold water (40°F.) dispersibility which remains unaltered on storage, (c) no oxidative damage, and (d) retention of good beverage quality for a year under ordinary refrigeration.

The process has been operated experimentally year-round in the pilot plant at economic rates despite seasonal variations in milk foaming properties. Plans are now being made for a retail market test which is a necessary step in the encouragement of commercial development of this unique process.

2. Cheese. The laboratory study of the preparation of low-fat cheese showed that the flavor and texture of the experimental cheeses were markedly affected by the amount of milk fat, moisture content, intrinsic milk lipases and rate and extent of acid development. The manufacturing procedures most directly related to the control of moisture, acidity and flavor were the homogenization of the milk fat, the fortification of cheese milk with dry skim milk solids, the type and amount of starter, the curd size and rate and extent of curd cooling and the temperature and type of cheese pressing. Pilot plant scale operations have yielded some cheeses of satisfactory quality but reproducibility has not been sufficiently good. Modification of procedures and slight changes in composition promise better control of variations. Shelf life beyond 8 to 10 weeks has been accomplished by blending and processing the

natural cheese. Tests by the Market Potential Branch (PRS) indicate that the new cheese should have good consumer acceptance. Since this low-fat cheese (5 - 7% milk fat and 55 - 59% moisture) has fewer calories than standard cheeses, it may be attractive to calorie counters.

In a study to determine whether *Salmonella* can survive during the manufacture of cottage cheese, selected strains of *Salmonella* were added to the cottage cheese milk. The analysis of 16 lots of cheeses made with 6 *Salmonella* test strains showed that a cooking temperature of 125°F. or above was required to destroy *Salmonella*. The rate and extent of acid produced by the lactic acid forming starter bacteria materially affected the destruction of *Salmonella*. Strains of *Salmonella* added to cottage cheese after manufacture continued to survive in the cheese without appreciable reduction in numbers for a 2- to 3-week period, which is a normal shelf life. These results provide reasonable assurance that *Salmonella* will not survive in cottage cheese if the cooking temperature is 125°F. or higher. However, if the cooking temperature is less than 125°F., the milk or milk fortified with nonfat dry milk should be pasteurized.

Research under a PL-480 grant at Kaira District Cooperative Milk Producers Union, Ltd., Anand, India, showed that an acceptable cheese can be made from buffalo milk to which nonfat dry (cow's) milk has been added to reduce the milk fat content.

In the research at National Dairy Research Institute, Punjab, India, milk clotting enzyme from selected strains of *Bacillus subtilis* were found to be sufficiently heat and pH stable for use in cheese-making. They also have proteolytic and lipolytic activities. They were used as rennet substitutes in making Cheddar cheese. The quality of the cheese and the chemical changes in it were practically the same as those in cheese made with rennet. Enzymes from *B. subtilis* are preferred over those from *B. megatherium* or *B. cereus*.

3. Removal of radionuclides from milk. Research under a U. S. Public Health Service contract with the Producers Creamery Company, Springfield, Missouri, on three full-scale runs showed that a combined anion-cation fixed resin bed system successfully removed about 99% of iodine-131 and 95% of strontium-85 from whole milk previously spiked with these isotopes. Flavor scores of the treated milk averaged 35.9 with the ADSA scoring system. The major flavor defect was described as "chemical" or "medicinal." Manufacturing costs for milk processed in this way was 6.3 cents per quart of milk exclusive of rent and administrative expense. The employment of a continuous contactor with a moving bed of ion-exchange resin to extract both radioactive iodine and radioactive strontium has been conducted under a contract between the U. S. Public Health Service and the Chemical Separations Corporation, Oakridge, Tenn. to which USDA contributed financial support. The contractor tested this equipment only with water and salt solutions. Although some refinement remains to be worked out with this system, it appears that the continuous contactor system for removal of radionuclides from milk is potentially useful. It is probable that more attention to operating details will be required than is necessary with the fixed-bed system. The fixed-bed system which has been

located at the Producers Creamery Company, has now been dismantled and shipped to the Public Health Service's Laboratory at Montgomery, Alabama. Similarly the continuous bed system will be removed to the Montgomery, Alabama, Laboratories for testing with milk.

Contract research at the Pet Milk Company, Greenville, Illinois, indicates that conventional pasteurization at temperatures from 169 to 172°F. for 16 seconds is inadequate to prolong milk stability to the 8 weeks required for iodine-131 decay. However, storage at temperatures as low as 32°F. materially improved storage stability. Processing temperatures up to 200 to 220°F. for 0.5 to 16 seconds extends milk stability at storage temperature of 40°F. or lower. High temperature processing, however, gave more heat-induced flavor component. Milk pasteurized at 220°F. for 16 seconds and stored at 40°F. or below maintained good quality for 13 weeks. This information should be useful to the market milk industry regardless of any iodine-131 problem.

4. Processing equipment. In grant research at the North Carolina State University, Raleigh, temperature sensors failed within a few seconds when positioned 1.56 inches downstream from the point of steam injection. Acoustic spectra were obtained for 3 different steam injectors operated at 3 processing temperatures in order to determine processing parameters. The acoustic spectra obtained were affected by processing temperature, distance of the sensor from the steam injection nozzle, injector design and liquid pressure downstream from the injector.

In 3 trials in commercial establishments in which foam-spray drying with liquified carbon dioxide was employed on whey, difficulties were encountered in removing the powder from the dryer and in no case was the powder produced as good as that produced in the Dairy Products Laboratory. The problem appears to be due to aggregation as the partially-dried droplets hit the Dairy Products Laboratory dryer wall, adhere, and are swept back into the drying air by the revolving sweep. Commercial driers are designed to prevent sticking to any surface. The data suggests that the desirable qualities of foam-spray dried products in the Dairy Products Laboratory pilot plant may be due to a combination of puffing and in-dryer agglomeration.

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MEAT UTILIZATION - FOOD

Eastern Utilization Research and Development Division, ARS

Problem. Livestock production is our greatest single source of farm income. For the past several years over 30 percent of cash receipts from farming were derived from livestock sales. Likewise, the major portion of our land is used to grow livestock feed and forage. Hence, any research which succeeds in stimulating an increase in the consumption of meat and livestock products will have a profound effect on agriculture as a whole. For example, it is estimated that a one-percent increase in meat consumption would require an increase in feed equivalent to 80-million bushels of corn.

The processing of meat and meat products also has an important effect on rural industry and rural employment. About half of our meat supply is derived from packing plants in rural areas. Many of these are small (the state of Pennsylvania alone has over 2,000 registered slaughterers) and cannot hope to maintain their own research facilities. They employ local labor, and their products are transported and sold by local truckers and business men. Thus increases in meat consumption and improvements in meat technology will contribute to increased rural prosperity.

Increases in livestock consumption depend primarily on the availability of wholesome and convenient products for purchase by the American consumer. In recent years the supply of such products has been threatened by the increased danger from infections by bacteria of the genus Salmonella. Research is needed which will lead to the development of meat products which, by virtue of the conditions under which they are processed, can be considered absolutely free of Salmonellae. A similar situation exists with respect to the toxins of Staphylococcus aureus, and to a somewhat lesser extent, those of certain anaerobic spore formers. An obviously important part of our research program must be devoted to providing the scientific "know-how" for the production of safer products for public consumption.

Increases in livestock consumption may be achieved through development of new or improved meat products, or through improved meat processing technology which results in lower costs. In addition, increases in the value of hides, animal fats, and renderers' proteins will benefit the livestock industry by providing additional revenues which could permit reduction in meat prices (thus stimulating consumption) or which could flow back through the marketing channels in whole or in part to livestock growers and feed producers. For example, it is estimated that loss of the market for hides would cause an increase of meat prices that would result in a decrease of 2 percent in meat consumption. Such a decrease would eliminate a market for feed equivalent to 160 million bushels of corn. Conversely, an increase in hide values would operate in the opposite direction and would result in greater income to the livestock industry and in increased utilization of feed grains.

Increased livestock consumption required both basic and applied research. Applied research is the forerunner of commercial practice and is an

indispensable element in successful development. But applied research depends on new knowledge which must be developed in fundamental studies. Our supply of fundamental knowledge must be maintained and expanded if applied research is to be effective and fruitful.

For the reasons given above, research which succeeds in increasing net consumption can have a powerful effect on American agriculture. The potential effect may be assessed from the facts that meat has a high elasticity demand (a 1-percent drop in retail prices will result in a 0.7-percent increase in consumption); the production of one pound of livestock requires the equivalent of 7 to 8 pounds of feed grains; and the present United States consumption of meat (174 lb/person in 1964) is still below that of Australia (234 lb.), New Zealand (222 lb.), or Uruguay (234 lb.). Economists predict that the 1967 United States consumption will be slightly lower than in 1964.

Attaining increased meat consumption and providing new technological information for small processors will require a vigorous and balanced research program. There is need for more applied research on processing and preservation, including expanded studies on increasing the efficiency of sausage production and on new dried or semi-dried and ready-to-eat products. Of even greater importance is the need for more basic research on the physical, chemical, and microbiological properties of meat to provide a fund of knowledge for future technological improvements.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists, biochemists, microbiologists, and food technologists engaged in both basic studies and in the application of known principles to the solution of problems in the processing of meat and meat products. The Department's research facilities are located at Beltsville, Maryland, and at Wyndmoor, Pennsylvania.

The Federal scientific effort devoted to research in this area totals 25.5 scientist man-years including 6.3 scientist man-years of contract and grant research. This effort is applied as follows:

(a) Research on chemical composition and physical properties involves 3.2 scientist man-years at Wyndmoor. A research contract at Louisiana State University provided for 1.0 scientist man-year to study the modification of muscle connective tissue constituents and their relationship to tenderness. This was completed during the reporting year.

(b) Flavor research is conducted at Wyndmoor, and involves 4.0 scientist man-years. Additional research under a PL-480 grant is in progress at Gdansk, Poland, on antioxidant components of wood smoke used in meat curing (5 years, 1963-1968).

(c) Research on color, texture and other quality factors involves 4.5 scientist man-years on investigations related to oxidation of tissue lipids at Beltsville, Maryland, and on fundamental studies of muscle pigment

chemistry at Wyndmoor, Pennsylvania. The relationship between heme pigments and oxidative rancidity in cooked and frozen meats is being studied at Florida State University under a grant involving 0.7 scientist man-year.

Another grant, for research on the noncarbonyl compounds associated with rancid meat, involves 0.5 scientist man-year effort at Rutgers University. Additional research is in progress under a PL-480 grant at British Food Manufacturing Industries Research Association, Leatherhead, Surrey, England, on specific reducing systems in pork muscle (5 years, 1964-1969).

(d) Research on microbiology and toxicology of meat and meat products involves 4.5 scientist man-years at Beltsville, Maryland. Contract research at Iowa State University, involving 1.2 scientist man-years, is concerned with a study of the fungi associated with cured meat. In addition, a recently-negotiated grant at the University of California, Davis, provides for a study of the effect of indigenous microflora on growth and toxin production of Staphylococcus aureus and undesirable Clostridia in cured meats. Research is also conducted under a PL-480 grant at Central Institute for Nutrition and Food Research, T.N.O., Utrecht, Netherlands, on the use of protozoa to detect harmful substances in meat (5 years, 1965-1970).

(e) Technology - process and product development involves 3.0 scientist man-years at Wyndmoor, Pennsylvania. A research contract at Michigan State University involving 0.8 scientist man-year is for the purpose of developing new smoked meat products. Another contract provides 0.7 scientist man-year effort for research at the University of Missouri to develop new meat products for freezing.

The development of new ready-to-eat meat products suitable for production in small, rural industries is being investigated under a contract (0.4 scientist man-year) at Southern University, Baton Rouge, Louisiana, and the reactions of muscle proteins as they relate to the thermal effects of meat processing and large-scale institutional cookery is being studied under a contract (0.5 scientist man-year) with Cornell University, Ithaca, New York. Contract research at Pennsylvania State University, University Park, involves 0.5 scientist man-year on development of fabricated meat products, including new lamb and mutton products.

In addition, research sponsored by the Department under PL-480 grants is in progress at Taiwan Provincial Chung Hsing University, Taichung, Taiwan, on preparation of new semi-dehydrated types of fried meat products (3 years, 1964-1967), and University of Helsinki, Helsinki, Finland, on influence of fats on flavor and aroma of fried sausage (5 years, 1963-1968).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 28.0 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

Freshly prepared pre-rigor muscle myosin of high purity was prepared from beef, pig and rabbit longissimus dorsi muscles. The enzymatic activity of these myosins towards adenosine triphosphate showed differences which are attributed to species characteristics and appears to affect meat quality. The method for measuring enzymatic activity was improved and the reproducibility in estimates with this new method is $\pm 2\%$. In contract research at Louisiana State University, histochemical studies showed that the amount and character of reticular fibers and degree of fiber contractions in muscle was related to tenderness. The content of acid- and salt-soluble collagens and total muscle calcium was not related. Other experiments dealt with the relation of the amount of acid mucopolysaccharides in bovine tissue to tenderness and to the movement of calcium ion in muscle tissue.

B. Flavor

A water extract of beef was dialyzed and flavor precursors were fractionated on polyacrylamide gel. One fraction had a strong roast beef aroma on pyrolysis and contained all of the threonine, proline, glutamic acid, alanine, valine, leucine and isoleucine in the diffusate. Water extracts of veal, pork and lamb showed a difference among the pyrolysis aromas of the diffusate, but exact identification of species could not be made. Fat played a major role in recognition of lamb flavor but was of less importance in the case of pork and beef. A standard fractionation procedure has also been devised and quantitative analytical methods for sugars, amino acids and other compounds have been established.

In research on flavor and aroma contributing factors in wood smoke, additional components identified were acetol, 2-cyclopentenone, methyl cyclopentenone and, tentatively, veratrol. When ferulic acid (an acid formed by the decomposition of lignin) was thermally decomposed, the phenolic products were the same as those in wood smoke. The fractionation of wood smoke by gas liquid chromatography permits the elimination of components not required for flavor and greater attention can thus be applied to the flavor components. Combination of a few readily available phenols gives a smoke flavoring mixture scarcely distinguishable from smoke condensates.

Of interest in the research under a PL-480 grant at the Technical University, Gdansk, Poland, is the finding that the compounds, 4-methyl-2-propyl-phenol, 3,4-dimethyl-6-ethylphenol, resorcylic acid, and 2,4,6-trimethylphenol are the most active antioxidants in smoke. Also, temperatures no higher than 400°C. in the smoke generator were found to be most effective, both from the standpoint of flavor development and antioxidant activity.

The investigations at Wyndmoor and Gdansk are, accordingly, providing significant and complementary results.

C. Color, Texture and Other Quality Factors

1. Stability. In studies of stored pork, bacon sides and mixtures of ground tissue fat and lean were treated with several salts before freezer storage. The salts were sodium chloride, sodium nitrite, calcium chloride, sodium nitrate, magnesium chloride, lithium chloride, potassium chloride, sodium sulfate and potassium sulfate. All salts showed some pro-oxidative effect. Sodium chloride-sodium nitrate mixtures have the greatest effect. In the case of sodium chloride the chloride ion did not appear to be responsible for the oxidative effect and sodium nitrite-heme combinations had an oxidative effect which was independent of sodium chloride.

The hydroperoxides of an oxidized lard were effectively reduced or otherwise decreased by stannous, ferrous and cuprous ions. However, these ions formed carbonyls in their action on the fat. These metallic ions have a remarkable oxidizing action on alcohols by producing significant amounts of monocarbonyls.

In grant research at Rutgers University, the volatiles from four samples of beef--laboratory boiled beef, pilot plant boiled beef, freezer-dried and boiled beef, and freeze-dried beef--yielded dissimilar gas chromatograms. Some volatiles appeared to contain sulfur. The volatile flavor components gave more than 100 peaks on an analytical gas chromatogram.

2. Meat pigments. Kinetic studies of the reaction of the heme pigments of meat with nitrite ion and various reductants to produce nitrosylmyoglobin (the undenatured cured meat pigment) indicated that a reductant-nitrite oxide complex was an intermediate in the reaction. The reductants were: ascorbate, cysteine, nicotinamide, adenine dinucleotide and hydroquinone. These studies seek to elucidate the formation of nitrosylmyoglobin and thus far have been carried out in vitro. The reaction mechanisms during actual processing are not the same, possibly because of participation by enzymes in the meat.

In grant research at the Florida State University, studies continued on enzymatic pathways for metmyoglobin reduction in meat. Monosodium glutamate and the glycolytic intermediates, fructose diphosphate or glycerol 3-phosphate, were found effective in promoting the metmyoglobin reduction in ground beef, aiding in good color retention.

Studies under a PL-480 grant at the British Food Manufacturers Research Association, Leatherhead, Surrey, England, of the mechanism of nitrosylmyoglobin formation showed that myoglobin was rapidly oxidized to metmyoglobin. The nitrosyl group was transferred from nitrosylferricytochrome-c to reduced metmyoglobin. The reduction and transfer were induced by nicotinamide adenine dinucleotide-cytochrome-c reductase. The nicotinamide adenine dinucleotide is oxidized in the process. Addition of succinate and nicotinamide to simulated cures accelerated color formation and suggests that a succinate-nicotinamide additive could be used beneficially in curing.

D. Microbiology and Toxicology

1. Microbial lipases. Study of the synthesis of Pseudomonas fragi lipase indicates that the enzyme is elaborated by cell envelope preparations. Concomitant with this elaboration, 2.6% of the envelope protein is released, indicating that the release of lipase is a part of the general release of several proteins. The ability of the lipase of Staphylococcus aureus to attack both the one- and two-positions of triglycerides is apparently due to broad specificity rather than to a mixture of two or more specific enzymes. Efforts to separate the enzymatic activity by ultracentrifugation and by column chromatography were unsuccessful. Four groups of microorganisms were distinguished on the basis of their action on monocarbonyls in rancid fat. Group I had little or no effect. Group II decomposes 2,4-dienals. Group III decomposes 2,4-dienals and 2-enals. Group IV decomposes the monocarbonyl fraction completely. The destruction of carbonyls by microbial activity suggests that selected bacteria might be employed to control the development of rancidity which sometimes occurs in fermented sausages.

2. Microbial metabolism. Combinations of sodium chloride, sodium nitrate, and sodium nitrite, in the concentration allowable in cured meat, reduced toxin production by Staphylococcus aureus, but not to a significant degree. Low temperatures, however, (below 10°C.) were very effective in reducing toxin production. Mutant cells, produced in the laboratory by artificial means, which were capable of growth at 5°C., were unable to produce enterotoxin at this temperature even when the amount of growth was comparable to that obtained at 37°C. The toxin is elaborated early in the growth cycle. There is evidence that Staphylococci caused more food poisoning cases attributed to meat than any other microorganisms and are involved in twice as many instances of food poisoning as Salmonellae.

In research under a PL-480 grant at Central Institute for Nutrition and Food Research, Utrecht, Netherlands, protozoa have not appeared to be very sensitive to toxins of microbial origin appearing in food; therefore, attempts were made to use easily grown small animals for detecting bacterial and fungal toxins and histamine phosphate. Water fleas were found sensitive to 0.01% histamine and 0.15 microgram/ml. aflatoxins B and G. The response time was 1 to 45 hours depending on the concentration. This sensitivity is the highest recorded so far. Brine shrimp were less sensitive to these two toxins, responding to 0.1% and 1.5 microgram/ml. respectively in 1-3 days. Guppies were sensitive to botulinus E (10 MLD/ml.), histamine (0.1%) and aflatoxin (0.15 μ /ml.).

Contract research at Iowa State University suggests that the manufacturer of "country cured" hams, fermented sausages and "country cured" bacon brings about a habitat which leads to similar fungal flora regardless of the geographical location of the processor. Lipolytic and proteolytic changes in fermented sausages examined at various stages of maturity showed that the maximum change in free fatty acids occurred between the fresh and intermediate stages of ripening. Free fatty acid formation appears to be highly important to flavor development. These studies should provide useful

information on the feasibility of adding known microorganisms to meats during curing.

E. Technology - Process and Product Development

1. Processing research. In new studies using modern methods of physical analyses, it was shown that the presence of liquid fat, whether added as such or produced through melting, contributes to instability in sausage emulsions. Since it is known that stable meat emulsions are not always formed even though temperatures below 65°F. are maintained, these results indicate that maximum temperature for successful emulsification cannot be arbitrarily fixed but depends on the melting characteristics of the fat used and the emulsifying capacity of the lean raw materials. As determined by differential thermal analysis, tissue fats melt primarily in two ranges, 48°-55° and 68°-88°F. for pork fat, and 45°-57° and 63°-99°F. for beef fat. Tests with low melting fat fractions resulted in emulsion instability at critical levels of liquified fat without relation to temperature per se.

Research during the past year has shown that the maximum temperatures attained during the processing of canned hams can be estimated at a later date by determining the amount of acid phosphatase remaining in the tissue. The accuracy obtained is greater than that possible by existing methods and thus forms a basis for improved regulatory procedures.

Studies of sausages produced with microbial inocula showed that a mixed Lactobacilli-Micrococci starter produced sausages of superior quality in a shorter time than uninoculated controls or sausages inoculated with pure cultures. Of particular interest was the ability of Micrococci to lower peroxide numbers. This research is conducted at the University of Helsinki, Finland, under a PL-480 grant.

2. New products. Contract research at Michigan State University showed that the phenol content correlated best with observed smoked aroma. The results of chemical and organoleptic analyses showed that phenol rather than acid content was significantly correlated with the perception of smoked flavor in bologna. Good results were obtained in getting a controlled uniform smoked flavor in bologna by incorporating smoked nonfat dried milk. Another new product developed was a meat loaf produced from smoked pork trimmings.

In PL-480 sponsored research at Taiwan Provincial Chung Hsing University, Tyndallization (intermittent sterilization) was effective in destroying both Staphylococcus aureus and PA 3679 at low temperature. This points to a commercial possibility for producing sterile, dehydrated meat by a novel application of Tyndallization.

Contract research at the University of Missouri showed that thick slices of "roastbeef," meat pie, beef with noodles, beef with spaghetti, and Swiss steak can be held in frozen storage for 12 months without marked decrease in quality. Storage temperatures were -5° to 0°F. for all products except beef

pie which was held at -14° to -18°F . A study of gravies indicated that a pectin-calcium chloride thickening agent resisted freezer damage better than several starches tested. The "roaststeak" material is a distinctive product developed by the contractor and has great potential in the restaurant trade.

Contract research at Cornell University on the reactions of muscle protein and thermal effects of meat processing has emphasized use of a calorimeter for precise measurements involving heat of transitions in meat fat. A micro-calorimeter was modified by the addition of an effluent analyzer which will be used in characterizing gaseous products formed in cooking.

Studies conducted under contract at Southern University dealing with production of barbecued-like products in small rural industries, indicated that considerable economies of time were possible when microwave heaters were used in comparison with conventional methods. An interesting point for further investigation was the finding that microwave heating resulted in greater fat losses than conventional heating methods.

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ANIMAL FATS AND OILS - INDUSTRIAL PRODUCTS
Eastern Utilization Research and Development Division, ARS

Problem. The 4-1/2 billion-pound-per-year output of inedible fats is one of the major products of the livestock industry. It also is one of major concern, because while production of animal fats has more than doubled in the last 15 years, its principal outlet (in soap) has declined sharply, and is still declining.

The best answer to the question of what to do with huge amounts of fats is to find new uses through utilization research. Already utilization research has played a leading role in finding new uses for over 1 billion pounds of animal fats, and thus helped retain markets for fats. Use of fat in animal feed which was developed through research, has now become the number one domestic use of inedible fats. There is need, however, for new uses not merely to retain or defend markets, but to expand them, and to upgrade the value of animal fats. The organic chemical industry presents a good opportunity for expanded markets, producing as it does a multitude of products--polymers, plasticizers, insecticides, herbicides, lubricants, paper chemicals--totaling 10 billion pounds. Animal fats possess "built-in" properties which make them potentially useful as raw materials to the chemical industry, but research must be done to realize this potential.

An increase of 1 cent per pound in the value of inedible animal fats would provide an additional revenue of \$40 million of the livestock industry. This additional revenue would help the industry and growers in the same way as revenue from other animal products and by-products.

The attainment of an increase in the monetary returns from livestock requires both applied and basic research. Applied research is the forerunner of commercial practice and is an indispensable element in successful development. But applied research is based on the foundation of fundamental knowledge that is acquired through basic research, and represents the exploitation of this fundamental knowledge. The supply of fundamental facts about composition of animal fats, methods of separation of constituents, preparation of chemical derivatives of constituents and determination of their physical and chemical properties must be maintained and expanded if applied research is to be most effective and fruitful. The need for basic research has been pointed out by the Commission on Increased Industrial Use of Agricultural Products, the National Agricultural Research Advisory Committee and by other responsible groups.

USDA AND COOPERATIVE PROGRAM

The Department has a broad program of basic and applied research at Wyndmoor, Pennsylvania, and at additional locations where contract and grant research is being carried out involving chemistry and physics, aimed at developing new and improved products from fats for use in industry. The total Federal scientific effort devoted to this program is 39.1 scientist man-years, of

which 4.8 are contract and grant research.

The research devoted to studies on chemical composition, physical properties and structure of animal fat amounts to 10.7 scientist man-years, of which 9.0 is at Wyndmoor. This research includes studies of composition of animal fats, the separation of constituents, the preparation of derivatives, the determination of physical and chemical properties of pure compounds and derivatives and, where applicable, computer programming of mathematical methods to expedite evaluation and interpretation of experimental data. Research at Villanova University, Villanova, Pennsylvania, is continuing under a contract to study special interrelationships within triglyceride molecules and a contract on the X-ray investigation of triglycerides, each involving 0.5 scientist man-year. A research grant involving 0.7 scientist man-year at Storrs, Connecticut, provides for the synthesis of pure glycerides.

Research sponsored by the Department under a PL-480 grant (5-years, 1966-1971) is in progress at Technical University, Gdansk, Poland, to study the thermally stable stationary phases for gas-liquid chromatography.

Research on chemical and physical investigations to improve products involves 25.3 scientist man-years at Wyndmoor and 3.1 in contracts and grants, a total of 28.4 scientist man-years.

Studies related to polymers and plastics include the synthesis of experimental monomers or comonomers and the preparation and evaluation of polymeric products derived from animal fat.

In other investigations, compounds derived from animal fats are used as starting material for the preparation of lubricants and lubricant additives.

Research on development of improved synthetic detergents based on animal fats includes preparation, testing of detergent power, and measurement of biodegradability of α -sulfo fatty acids and their esters, tallow alcohol sulfates and other fat derived materials. The high pressure hydrolysis of animal fats to alcohols without simultaneous chain saturation is being investigated at Swift and Company, Chicago, Illinois, under a research contract involving 1.1 scientist man-years.

At Lehigh University, Bethlehem, Pennsylvania, the interfacial absorption characteristics of wetting agents and detergents are being studied under a research contract involving 0.4 scientist man-year. A contract with Archer-Daniels-Midland, Minneapolis, Minn., equivalent to 1.1 scientist man-years, provides for research on additive chlorination and hydrogenolysis of animal fats.

Exploratory investigations, employing novel and/or improved reaction techniques are conducted at Wyndmoor to provide new chemical derivatives from animal fats. A research grant with the Hormel Institute of the University of Minnesota at Austin, Minnesota, involving 0.5 scientist man-year provides for the investigation of the ozonization of animal fats.

In addition, research sponsored by the Department under PL-480 grants is in progress at the following foreign institutions:

1. Technical University, Gdansk, Poland, on kinetics and thermodynamics of fat autooxidation (5 years, 1964-1969).
2. "L. Torres Quevedo" Scientific Instruments Institute of the "Juan de la Cierva" Foundation for Applied Research, Madrid, Spain, on cocoa butter substitutes from animal fats (5 years, 1962-1967).
3. University of Bombay, Bombay, India, on the preparation and properties of long chain sulfated monoglycerides (5 years, 1964-1969).
4. Universite d'Aix-Marseille, Marseille, France, on hydroxylated fatty derivatives (5 years, 1962-1967).
5. Institut des Corps Gras, Paris, France, on autooxidation of fat at low temperatures (3 years, 1965-1968).
6. Centre National de la Recherche Scientifique, Paris, France, on polyhalogenated fatty acids and their derivatives (2-1/2 years, 1966-1968).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2.9 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure

In contract research at Villanova University the mathematical study aimed at theoretically determining the overall shape and spacial interrelations within a triglyceride molecule in the liquid state has progressed to the point where computer programs have been written for the nonbonded interaction energy of various conformers of organic molecules related to triglycerides. Since the population distribution of the various conformers of a flexible organic molecule depend on the energies of these conformers, which in turn depend on the nonbonded interaction energies, the method should lead to better understanding of triglyceride molecules. The method chosen for computing the nonbonded interaction energies is a modification of the Hartree self-consistent field procedure.

Under another contract at Villanova, X-ray structure analysis of the β -form of β -11-bromoundecanoyl- α,α' -dicaprin has verified the expected parallel alignment of adjacent chains and the planar configuration of the molecule in the molecular crystals. The unit cell dimensions have been determined and the space group found to be $P\bar{1}$. The unit cell is triclinic. This work represents the first time that the structure of a mixed triglyceride has been determined in such detail.

In research at EU the utility of the procedure for the rapid conversion of glycerides to fatty acid methyl esters has been extended to include oils which contain hydroxy or epoxy groups. A similar procedure, but somewhat slower (20 minutes), has been developed for the trans-esterification of cholesteryl esters to methyl esters of cholesterol. This is accomplished without degradation of the steroid moiety, which has been a problem with most analytical methods. An investigation of the partition of lipids between two immiscible solvents from a thermodynamic point of view has been initiated and ternary diagrams for methyl oleate-hexane-acetonitrile and methyl palmitate-hexane-acetonitrile systems have been constructed. The analytical procedures were applied to samples from a number of different sources including human aortas with varying degrees of atheromatosis, to teeth lipids, blood plasma, skin tissue and to various phospholipids, all with satisfactory results.

Under grant research at the University of Connecticut, Storrs, triglycerides of the highest purity have been prepared and furnished to EU. The compositions are POO, OPP and POS, where P is palmitic acid, O is oleic acid and S is stearic acid. Also one diglyceride (1,3 S-P) and one monoglyceride (1 monooleate) were furnished. In somewhat smaller quantities there were prepared in high purity the materials S-S, O-O and LPP, where L is linoleic acid. The techniques and procedures for preparing these high purity mixed acid triglycerides in quantity is expected to be valuable to firms manufacturing standards for gas and thin-layer chromatography.

A computer program developed at EU permitted the testing by computation of several modes of operation of a countercurrent distribution apparatus and the influence of these modes on the effectiveness of separation of two compounds. The program was subsequently revised to make it possible to follow elutions and frontal analyses. The computer was also employed for a variety of other tasks including the correlation of experimental data with theoretical formulae for dielectric properties, for computing amino acid analyses from an automatic amino acid analyzer, and for subdividing an infrared band into two component peaks. Also, a general purpose program has been written to replace many routine desk calculator procedures. Many desk calculations can be saved with this new program.

Research conducted at EU showed that while the proton magnetic resonance (PMR) spectra of C_{18} acetylenic acids and methyl esters with the carbon-carbon triple bond located at various locations are unexpectedly complex, the PMR spectra can be used to locate the carbon-carbon triple bond in the C_{18} carbon chain. The spectra of the 5-, 6-, 7-, 8-, 9-, 12-, 13-, and 15-octadecynoic acids are unique. The 10- and 11-octadecynoic acids gave spectra

indistinguishable from each other but different from the spectra of other C₁₈ acetylenic acids. When formic acid, methyl formate and some of their deuterated forms were subjected to infrared analysis it became possible to calculate 90 vibrational frequencies of the eight molecules concerned, with an average error of less than 0.5%. A determination of bond stretching and bond bending force constants permits the calculation of characteristic group frequencies with a high degree of accuracy.

In research at Technical University, Gdansk, Poland, a new gas chromatograph was designed to make precise measurements for determining liquid phase thermostability. An equation, based on the dependence of the vapor pressure on temperature as defined by the Clausius-Clapeyron formula, was derived for describing the dependence of the thermostability on temperature.

B. Chemical and Physical Investigations to Improve Products

1. Plastics investigations. A number of urethane foams based on polyols from glycerides such as hydroxylated glycerol trioleate, monooleate, lard, neatsfoot and soybean oil were evaluated. The properties of the foam (density, compressive strength and open cell content) were somewhat inferior to foams prepared previously in this laboratory or commercially. 2-Ethylhexyl diepoxy-stearate compares favorably with commercial epoxy-containing plasticizers and could be useful either as a primary plasticizer or in combination with other plasticizers as a plasticizer-stabilizer.

Experimental work on chain transfer in the copolymerization of allyl monomers as vinyl monomers permitted the derivation of a simple general empirical relationship for the estimation of molecular weights of copolymers of a large number of vinyl monomers with many allylic compounds. The result suggests that commercial polymers such as polyvinyl chloride may be modified with monofunctional fatty allylic comonomers to provide polymers whose molecular weights and viscosities would be satisfactory for use in paint films.

2. Detergents investigations. The more soluble fat-based detergents (unsaturated tallow alcohol sulfates and esters of α -sulfonated acids) solubilized the less soluble tallow-derived detergents (disodium salts of α -sulfonated acids and saturated alcohol sulfates). This improvement of solubility improves utility at lower washing temperatures and makes them more useful for liquid formulations. Unsaturated ether alcohols prepared from oleyl alcohol and ethylene oxide, propylene oxide or butylene oxide reacted readily with conventional sulfating agents and left most of the double bond untouched. Unsaturated ether alcohol sulfates are very soluble detergents with good lime soap dispersing properties. They may be useful for combining with less soluble tallow based detergents. Past research at EU contributed to the pilot-plant development of phenylstearic acid and hydroxy-phenylstearic acid announced recently by Armour & Co., and Archer-Daniels-Midland Company.

Improved analytical techniques indicate that linear alkylbenzenesulfonate degrades about 75% after 12 days. Sodium isopropyl- α -sulfo-stearate gives 45% of a sulphur-containing residue which is not degraded after 12 days.

Methylene blue analysis, however, shows complete degradation of both compounds in about 5 days. The new methods based on carbon analysis of detergents and degradation products and on analysis for sulfate ion permit better understanding of the products of degradation in streams. These methods should show differences in products of degradation not now evident by present methods of determining pollution by detergents (foam and methylene blue tests).

In contract research at Lehigh University investigation of selected esters of the wetting agent and detergent types was continued. Two wetting agents and two detergents were investigated, sodium hexyl and heptyl α -sulfopelargonate and sodium methyl α -sulfomyristate and α -sulfopalmitate. The rate of adsorption of these has been followed by breaking a vial of activated carbon into a solution of each material. The concentration was followed by measuring the electrical resistance of the solution. The wetting agents reached a constant value of resistance much more rapidly than the detergents. The rate of adsorption on the carbon measured in this way may prove to be a valuable method for making fundamental distinctions between detergents and wetting agents.

In contract research at Swift & Company, Chicago, progress has been made in retaining unsaturation in the hydrogenolysis of animal fats to alcohols; methyloleate was converted to oleyl alcohol with 98% reaction and a hydrogenolysis/hydrogenation ratio of 6. The product of the reaction is potentially valuable as a detergent intermediate. The oleyl alcohol produced may also be useful in cosmetics, textiles and printing inks, and as a general chemical intermediate. The reaction conditions were one hour at 350°C. and 3,000 p.s.i. with a Cr-Zn-Cd-Al catalyst.

Contract research has begun with the Archer-Daniels-Midland Company on the additive chlorination and hydrogenolysis of animal fat. Additive chlorination takes place readily with oleic acid, methyl oleate or oleyl alcohol in methylene chloride at -15° to -20°. Additive chlorination of oleic acid in methanol gave the chloro-methoxystearate. Additive chlorination gives product suitable for hydrogenolysis experiments. The adjacent chlorine atoms in the 9-10 position are fairly unreactive chemically.

In related PL-480 sponsored research at Centre National de la Recherche Scientifique, Paris, chlorination of saturated fatty materials to a chlorine content of up to 71% has been achieved by electrolysis methods, electric discharge and photo-chlorination. Products of intermediate chlorine content have been prepared, and some of these have extremely interesting olefinic functions.

At the University of Bombay, India, sulfated monoglycerides of lauric, myristic, palmitic and stearic acid were prepared in a pure state. Surface and interfacial tension, foam height, Ca^{++} stability, and emulsifying and lime soap dispersing properties were measured and compared with sodium dodecyl sulfate. Tallow derivatives had the best Ca^{++} stability, lime-soap-dispersion and emulsifying properties.

3. Lubricant investigations. The cyanoethylation of hydroxylated fatty esters has been achieved. Using excess acrylonitrile as solvent has led to yields in the 90-95% range and considerable progress has been made in converting the resulting β -cyanoethoxy ethers to β -carboxamidoethoxy ethers without significant losses due to ether cleavage. Two new types of materials derivable from fats and oils have been isolated, dihydroxytetrahydrofuran derivatives from diepoxides and hydroxyamide from aziridine. Since the internal aziridines react with a variety of carboxylic acids (pelargonic, stearic, benzoic and para-methoxy-benzoic) to form hydroxyamides, exploitation of this reaction in lubricant applications will be investigated.

Preparation and evaluation of larger quantities of pure α -branched fatty acid esters for use as lubricants show that these compounds are equal to or superior to most other organic materials in viscosity, viscosity index, thermal stability and hydrolytic stability. In the wear test they show good results when used alone but are not susceptible to substantial improvement by known additives. Several new esters were prepared including the methyl ester of "isostearic acid." A commercial product consisting of a mixture of numerous branched acids was added to 1-decene to prepare a product with potentially useful lubricant properties.

4. Exploratory reactions investigations. The enol ester, isopropenyl stearate, is effective in stearoylations because it is a source of latent hexadecylketene, the actual acylating agent. Stearoketene dimer (2,4-dihexadecylcyclobutane 1,3-dione) has been obtained pure in high yield. The generation of stearoketene in the presence of hydroxylamine gave the previously unknown distearoyl and tristearoyl dihydroxamic and trihydroxyamic acids. The ketenes are capable of attacking amides and hydroxylamines and, in general, materials with active hydrogen functions.

The reaction of aroyl and diacyl peroxides with iodine in various solvents appears to be a new class of reaction. Thus, benzoyl peroxide and aliphatic acids and iodine react to give alkyl iodide derived from the aliphatic acids. This reaction offers a valuable alternative to the use of expensive silver-salt preparations for the preparation of alkyl iodides.

In grant research at the Hormel Institute of the University of Minnesota, progress has been made in techniques applied to the destructive distillation of ozonides. It is possible to select the operating conditions for a centrifugal type molecular still so as to either distill the ozonides of fatty esters for purification purposes or to thermally decompose the ozonides to obtain aldehydes and aldehydates in high yield.

At the Institut des Corps Gras, Paris, a detailed study has been completed of the volatile and nonvolatile products of the air oxidation of oleic acid at 40° and 20°C. Volatile organic materials include bis-(1-hydroxyheptyl) peroxide, saturated straight chain aldehydes ($C_6 - C_{10}$) and propionic, acetic and formic acids. The grantee concludes that these compounds, as well as CO_2 and part of the water, arise from the splitting of the oleic acid hydroperoxide to give decanol and nonanol. Further stepwise degradation of the

aldehydes follow. The nonvolatile portion consisted of oxymonomers and oxypolymers.

In a study of the autoxidation of methyl erucate at Technical University, Gdansk, Poland, mathematical equations for change in double bond (as measured by iodine values) and change in hydroperoxide content as a function of time have been devised. The data indicate the presence of an undefined, initial catalyzing substance and that the reaction follows a three-step kinetic scheme from methyl erucate to peroxide decomposition products proceeding through an activated complex at each step.

Allylically brominated oleic acid has been converted into allylically hydroxylated unsaturated acids in good yields in a process employing milk alkali salts. In this research at Universite d'Aix, Marseille, France, selenium dioxide has also been used to produce allylically hydroxylated products in fair yields, while mercuric acetate gives nearly exclusively monohydroxy-allylic derivatives.

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Chemical and Physical Investigations to Improve Products

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HIDES AND LEATHER UTILIZATION

Eastern Utilization Research and Development Division, ARS

Problem. To maintain the utilization of animal hides and skins at a profitable level there is need to find new products and processes to provide outlets for about 13 million cattlehides that are now available in excess of domestic needs. The foreign markets that currently absorb these surplus hides are also threatened by the increased hide production and decreased per capita use of leather (the principal outlet for hides) that have dislocated U.S. markets and caused prices to drop so precipitously in the last 10 years. To meet this problem there is need for upgrading the quality of raw hides and skins, for reducing the costs of producing leather, and for developing new and nonconventional products from collagen. To achieve these objectives research is needed to develop improved curing processes and agents, more effective control measures for (ante mortem) defects such as grubs, brands and parasite damage, and improved methods of take-off. Fundamental research is needed on the composition of hides to provide basic information on the chemical, physical and physical-chemical properties and reactions of collagen and other hide components for use in studies on chemical modification and on the development of new and improved products and processes. Development of new, more rapid and economic processes for curing, handling, unhairing and tanning hides is needed to reduce the cost of producing leather. There is also need for research on the chemical modification of hide proteins to develop leather products with such improved "built-in" properties as increased resistance to wear, scuffing and deterioration from perspiration, enhanced washability, dry-cleanability and improved dyeability. There is also need for research on the physical and chemical properties of collagen to obtain information for use in dispersing and regenerating the fibrous structure without degrading its unique properties for developing nonconventional products that will provide new outlets and markets for hide proteins, with special reference to the field of edible products.

USDA AND COOPERATIVE PROGRAM

The department is conducting a broad program of basic and applied research on hides, skins and leather at Wyndmoor, Pennsylvania, and at additional locations where contract and grant research is being carried out; this involves physicists, chemists, biochemists, microbiologists and leather technologists.

The Federal scientific effort devoted to the over-all program totals 27.2 scientist man-years, including contract and grant research equivalent to 2.1 scientist man-years per year, applied as follows:

(a) Research on chemical composition, physical properties and structure of hides and leather involves 10.7 scientist man-years at Wyndmoor. One line of investigations is concerned with the isolation of collagen and other hide components and with basic research on the chemistry of collagen. This research is supplemented by (1) a grant (0.6 scientist man-year) at Northwestern University School of Medicine, Chicago, to apply physical chemistry

techniques to protein solvent interactions of collagen and gelatin, (2) a contract (0.6 scientist man-year) at the same institution to study relation of high molecular weight gelatin to collagen, (3) contract research involving 0.5 scientist man-year at Midwest Research Institute, Kansas City, Missouri, to study the dispersion of collagen, and (4) a PL-480 grant at the University of Turku, Finland, (3 years, 1965-1968) for basic investigations on the structure, biosynthesis and maturation of collagen.

Other investigations at Wyndmoor are concerned with the relation of hide composition and structure to leather properties. Additional research is in progress at the Central Leather Research Institute, Madras, India, under PL-480 grants on (1) the hydrothermal shrinkage of collagen and leather, (3 years, 1964-1967) and (2) comfort properties of shoe leather (5 years, 1964-1969). The contract research at the University of Cincinnati, Cincinnati, Ohio, on the abnormalities of leather characterized by a depleted, mushy texture was completed during the reporting year (0.4 scientist man-year).

(b) Chemical and physical investigations to improve products involves 8.4 scientist man-years at Wyndmoor. This research is concerned primarily with the investigation of chemical modifications of hides prior to and during tanning operations to provide improved leather.

Research sponsored by the Department under PL-480 grants is in progress at Central Leather Research Institute, Madras, India, on (1) polyphenolic tanning compounds (5 years, 1962-1967) and (2) preparation and determination of physico-chemical properties of polypeptidyl derivatives of collagen (5 years, 1966-1971), and at the British Leather Manufacturers Research Association, Surrey, England, to investigate chemically reactive compounds for improving leather stability (5 years, 1963-1968).

(c) Technology - process and products development involves 6.0 scientist man-years at Wyndmoor. Research includes development of new tanning processes for hides and skins to provide products of superior durability and development of regenerated collagen products.

Additional research under PL-480 grants is in progress at Central Leather Research Institute, Madras, India, on (1) relation of hide quality to tanning rate (5 years, 1962-1967), (2) radioactive tracer study of mineral tanning (5 years, 1965-1970), and (3) rapid tannage of sole leather (5 years, 1965-1970); and at the Leather Research Institute, T.N.O., Waalwijk, Holland, on kinetics of chrome tanning (4 years, 1964-1968).

PROGRAM OF STATE EXPERIMENT STATIONS

State stations reported no research in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure.

1. Protein constituents and collagen. Nuclear magnetic resonance studies of the phenylalanine cation and anion in aqueous solution suggest that the relative potential energies of three rotamers of this substance are dependent on temperature and concentration. The dependence correlates with the dielectric constant of the aqueous solutions. Application of infrared spectroscopy to the characteristic vibrational frequencies and other physical constants for different configurations of proteins in deuterium oxide solution shows that the fine structure of certain infrared bands permits distinguishing between the α -helical extended and solvated random configuration for these proteins.

The autoclaving conditions which almost completely dissolve collagen solubilizes only 12% of epoxy resin-treated collagen. Under these conditions the average peptide length of the solubilized material was 20 units for collagen and 6 units for the epoxy-treated collagen. Controlled experiments with standard amino acid mixtures treated with aldehydes showed that aldehydes caused total disappearance of the tyrosine of collagen. It was also found that even small amounts of decolorizing carbon would cause the complete disappearance of tyrosine, phenylalanine and methionine and a partial disappearance of leucine, isoleucine, lysine and arginine from collagen hydrolyzates. The interference of amino acid analysis by aldehydes and decolorizing carbon is not widely known or appreciated and this possibility should be considered in interpreting results from experiments known or suspected of involving these treatments.

Contract research at the Midwest Research Institute, Kansas City, Missouri, showed that dispersed collagen sols can be obtained without the use of acids by liming hides for six weeks or longer. Relatively concentrated dispersions have been prepared from the hydrochloride of collagen. Under acid conditions the sodium chloride concentration considerably affects the dispersibility of the collagen hydrochloride. Fibers and films have been prepared from these collagen dispersions. In grant research at the Northwestern University School of Medicine, Chicago, gelatin was employed to investigate solvent-solvent and solvent-peptide interactions in the solvent pairs formic acid-methyl acetamide, formic acid-methyl formamide, formic acid-dimethyl sulfoxide and formic acid-acetonitrile. The interaction potential between the solvent system and solubilized collagen was examined for the solvent pairs formic acid dimethyl-formamide, formic acid-dimethylsulfoxide, formic acid-water and formic acid-acetonitrile. These data support the idea that the solubilized collagen molecule is stabilized by one definite type of intramolecular force. Analysis of mutarotation data showed that water has no specific effect on the mutarotation of poly-l-proline and has a large effect on stabilizing poly-l-hydroxyproline. The effect of water suggests that this force is either hydrogen bonding or hydrophobic bonding.

Two new and significant findings have resulted from research under a PL-480 grant at the University of Turku, Finland. The requirement of calcium for the maturation of collagen may have significance to our own studies on dispersibility of mature collagen. The procedure for the isolation of large collagen fragments after partial degradation with pepsin will aid materially in future studies of collagen structures.

2. Hides and leather. It has been conclusively established that a defect known in the trade as "pulpy butts" which produces weak leather is due to an abnormal vertical alignment of fibers and usually a high fat content in the hides themselves. It occurs mainly in a localized area on the back of a small percent of thick, heavy Hereford hides and appears to be of a genetic origin. The defect "cockle" in sheepskin, in which nodules in defective skins assume the form of hard ridges in the finished leather, makes such areas unfit for either grain or suede types of leather. The problem is seasonal, occurring only during the colder months. Early in the season the lesions are small but gradually become more numerous and more elevated, tend to be aligned in rows and can cover almost the entire skin. It is impossible to detect the early lesions in unprocessed skin even after shaving off the wool. The application of differential thermal analysis and dynamic mechanical testing showed that the shrinkage temperatures of leathers stored at 23°C. and 50% relative humidity decreased with storage time. Sole leather exhibited most resistance to change in shrinkage temperature while chrome-tanned vegetable retanned leathers showed the greatest variation in shrinkage temperature under the various conditioning treatments used.

The automated equipment used to solubilize calfskin collagen has resulted in solubilization of 7% of the calfskin corium used as the source of collagen. In previous runs with manual adjustment of solubilizing condition the yields of solubilized collagen ran consistently below 1%. Citrate bound to the corium after exhaustive solubilization showed eight citrate residues per un-solubilized collagen molecule, the same as previously observed for reconstituted collagen. The corium residue from the automated process yielded no further solubilized collagen under treatment of a variety of other solubilizing agents. Other investigators have reported the occurrence of several species of collagen, each of which is amenable to a different solubilizing agent, but these experiments show that under optimum conditions a single solubilizing agent is adequate. The citrate determinations indicate similarity between reconstituted collagen and the corium after complete solubilization.

Studies under a PL-480 grant at the Central Leather Research Institute, Madras, India, indicate that various factors influence the hydrothermal shrinkage of animal hides. These include: (a) swelling, (b) deposition, (c) fiber structure, (d) drying, and (e) chemical binding. The behavior of skin or leather is the sum total of the behavior of the collagen fibers. The shrinkage properties vary with the treatments given the collagen.

Under another PL-480 grant at the Central Leather Research Institute, studies have continued on the various effects of moisture upon foot comfort. The experiments of the previous year involved water absorption measurements on

leather samples under laboratory controls. These techniques have now been applied to leather samples placed at twelve locations both inside and outside the sock under actual wear conditions. Since these samples were equilibrated at 65% relative humidity before the experiments and only increases in moisture content were detected, the micro climate within all regions of the shoe must be above 65% relative humidity. The toe parts of the shoe show the greatest increases in moisture uptake of the samples. When water vapor impermeable materials are placed between the samples and the outside of the shoe, there is an increase in the moisture uptake proving that transpiration of moisture through the shoe is effective in reducing the humidity or moisture conditions within the shoe. It has been determined that both the left and right foot have comparable moisture relationships; and, therefore, one foot can be used as a control for an experiment performed on the other.

B. Chemical and Physical Investigations to Improve Products.

1. Mannich reactions. The reaction of malonic acid and formaldehyde and the hide protein results in a new substrate with enhanced binding power for chrome and other mineral tanning agents. The enhanced binding power is a result of the introduction of additional carboxyl groups on to the collagen. Amino acid analysis indicated that chemical modification was accomplished and that generally the lysine, hydroxylysine and histidine residues were involved. The products when retanned with chrome showed greater stability to aging and greater resistance to deterioration from hot soap solution than conventional chrome-tanned leather. The Mannich reaction thus appears to be an easy method for modifying hide substance.

2. Other chemical modifications. Amino acid analyses showed that approximately two-thirds of the lysine originally present in sheepskin disappeared after tannage with glutaraldehyde. In addition some hydroxylysine also appeared to be lost. No other amino acids appeared to be involved in the fixation of glutaraldehyde. A series of drycleaning tests on suede garment leathers showed that glutaraldehyde retannage and a fat liquor based on Deriphats ($\text{RNHCH}_2\text{CH}_2\text{CO}_2\text{H}$ and derivatives) gave products much more retentive as a fat liquor than commercial fat liquors. Three drycleaning agents were used--Zalclene, Stoddard solvent and perchloroethylene. In studies of the chemical nature of the product produced by tanning collagen with glutaraldehyde it was found that tests with 3-methyl-2-benzothiazolone hydrazone hydrochloride (NBTH reagent) show that collagen tanned with glutaraldehyde has free aldehyde groups.

Combination tannages with resorcinol in conjunction with methylolated products gave best results with the combination of resorcinol and dimethylol-propylene-urea. The product was a white soft leather. Tannage with dimethylol-urea followed by zirconium or chrome gave a soft leather resistant to artificial perspiration. A preliminary test on the dimethylol-urea tanned leather indicates good resistance to deterioration by acidic peroxide (a standard test for bookbinding leathers).

In research on polyphenolic tanning compounds under a PL-480 grant at the Central Leather Research Institute, Madras, India, grantees have obtained a greater knowledge of the composition and properties of babul, dhawa and goran tanning materials. Work is concentrated on extraction of the tanning materials and their complexing with chrome as tanning agents.

Research on the modification of collagen with aldehydes under a PL-480 grant with the British Leather Manufacturers Research Association, Surrey, England, was continued. The reactivity of different aldehydes was systematically explored. Characterization of the types of products formed has provided information on the possible mode of action and on the structure of the addition products. The interpretations are tentative, but are a basis for more definitive experiments.

3. Pretannage investigations. Aqueous butyl carbitol (approx. 15% in carbitol), used to dehydrate animal hides and skins, inhibits both bacterial and mold growth. The effectiveness of dehydration of animal hides and skins by this method can be evaluated by measurement of the apparent density of the dehydrated product. The method is promising and appears to reflect the nature of the fiber separation. Dehydrated goat skins when processed commercially gave leather considered equal to goat skins produced in the usual way. As raw hides and skins are perishable, dehydration, if it can be accomplished economically, becomes an attractive method for preserving and stabilizing hides.

Contract research at the University of Cincinnati indicates that the extraction of fresh hides with 1% sodium chloride solution prior to brine curing has only slight effect on the characteristics of the unfinished leather. It is concluded that it is not economically justifiable to extract the non-collagenous proteins from cattle hides prior to curing. It is also concluded that the water wash now used by some packers prior to fleshing and demanuring will not harm the quality of the hides and may be beneficial. This is the final report of a previously completed contract.

C. Technology - Process and Product Development.

1. Glutaraldehyde tannage. A large-scale tannery pack of shearlings made with glutaraldehyde and an appreciably higher amount of basic chromium sulfate yielded medical pads with an increased degree of hydrothermal stability which provides a greater margin of safety in laundering. After six months use in Philadelphia hospitals these shearlings are washing and wearing well.

Bookbinding leather made by tanning sheepskin with glutaraldehyde without the usual 5% potassium lactate buffer yielded excellent (but not perfect) resistance to the standard test for bookbinding leather which uses a combination of sulfuric acid and hydrogen peroxide as the test reagent. Since bookbinding leather is an imported commodity, oxidation-resistant leather might provide a market for domestic hides and skins.

2. Chrome tannage. The exchange of sulfate tagged with S^{35} atoms shows slow

and fast exchange rates which indicate more than one chromium complex is present in chromium tanning materials. The presence of OH groups in the complex is responsible for the fast exchange rate. Fractionation of these complexes on Dowex 50 ion exchange columns demonstrated complexes with 1, 2 and 3 positive charges. The complexes with 2 and 3 charges showed no exchange between bound and free sulfate groups. Exchanges of chromium complexes on carboxylic and sulfonic type ion exchange resins show that some species of complex which bind readily to carboxylic type resins do not bind to sulfonic type resins. This supports the present belief that the chromium tanning materials are bound chiefly to the carboxylic groups of proteins. This research was conducted under a PL-480 grant at the Central Leather Research Institute, Madras, India.

In the research under a PL-480 grant at the Lederinstitut, T.N.O., Waalwijk, Holland, the influence of temperature, basicity, and concentration of chrome tanning agents were studied simultaneously. Basicity effects were more pronounced as temperature increased, but only for the first period of tanning.

As masking agents, sodium salts were effective in this order: butyrate, formate, propionate and acetate. They stabilized the chrome complex and reduced the amount of chrome fixed by a moderate amount at pH's of 3.0 - 4.0. A small amount of oxalic acid was observed to increase the fixation of chrome.

An accurate method of measuring ionic sulfate in tanned leather was developed.

3. Other tanning research. Research at the Central Leather Research Institute, Madras, India, is proceeding under PL-480 grants to study (a) the rapid tannage of sole leather and (b) relation of hide quality to tanning rate. In the former, Indian tanning materials were applied in rapid tanning of heavy leather in small-scale experiments. Bringing the pelt to its isoelectric point before vegetable tanning increased rate of penetration without adverse effect on the fixation of tans and leather properties. Osmotic process and the chrome pretreatment method gave leathers of good yield and good physical properties. Tanning at higher temperatures gave the quickest penetration, but the feel and the physical properties of the resultant leather were not very satisfactory.

In the latter, many of the variables affecting hide quality and leather properties have been studied. A significant contribution has been the development of a laboratory test method for the determination of hide quality. This is based on the measurement of hydroxyproline in the soak waters from the hides. Hydroxyproline being an amino acid characteristic of collagen, its presence correlates with conditions of hide history that lead to degradation of hide substance. Changes in the noncollagenous proteins in hides caused by different curing procedures were evaluated. The history of the hide (slaughtered or fallen) was also considered. Procedures for controlled tanning and for determining the extent of tanning were standardized.

4. Regenerated collagen products. Since limed hides are commercially available and yield dispersions with the same properties as enzyme-unhaired hides, the latter are no longer under study to produce collagen dispersions. Two routes to a collagen dispersion useful in food applications have been applied to lime unhaired hides, (1) a cold acid process and (2) a warm acid process. Films obtained from the warm acid process did not dissolve in warm water and shrank like native collagen rather than dissolving like gelatin. Reducing sugars are being evaluated as cross-linking agents in such films. Cross-linked films are pliable, elastic, easily stripped from a surface and resist disintegration at 170°C. in the smokehouse.

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WOOL AND MOHAIR UTILIZATION

Western Utilization Research and Development Division, ARS

Problem. Traditional markets for wool and mohair have been lost to synthetic fibers because consumers prefer garments that hold their pleats and creases, resist shrinkage and wrinkling during washing, and dry quickly. Natural wool and mohair outclass the synthetics in tailorability, comfort in wear, appearance, and hand, but lack certain features now being exploited by the promoters of synthetics. Furthermore, some current processing methods damage, distort, or weaken wool and mohair fibers and injure performance and appearance of the fabric. We need processes that will modify natural fibers to give a range of comfortable and attractive fabrics that resist deterioration in processing and wear. Fabrics must be durably resistant to wear, wrinkling, pilling, abrasion, yellowing, soiling, felting and relaxation shrinkage, acid and alkali weakening, insects, and micro-organisms. New markets in industrial and other uses would develop for new types of fabrics, woven and non-woven, made from natural wools and from blends of wool with modified wools or other fibers. Wool could have a part of the new, developing market for stretch fabrics if we could practicably impart permanent stretch into wool yarn. Research toward such developments requires fundamental information on the chemical, physical, and structural nature of natural fibers and their modified products.

To sustain a stable sheep and wool industry in the United States, mills must be supplied with processing information on new and improved wool and mohair products. Synthetics have cut into wool markets because the synthetics are uniform in price and quality and because detailed processing information is available from producers.

USDA AND COOPERATIVE PROGRAM

The Western Utilization Research and Development Division conducts a broad basic and applied research program on wool and mohair to develop new and improved fibers and fabrics that can increase markets. Fundamental research seeks new facts on chemical and physical properties of natural fibers, and we use such knowledge to modify fibers and fabrics so that they will resist degradation by heat, light, chemicals, staining, abrasion, and insects; retain creases; shed wrinkles; and require little care. Department scientists bring research results to the industry through technical publications, public service patents, exhibits, news media and conferences.

The Federal program is conducted at the Division headquarters at Albany, California; by contract in Durham, North Carolina, and Washington, D. C.; and by grant funds under P.L. 480 in India and Sweden.

The Federal program of research in this area totals 26.4 scientist man-years, including contract research. Of this number, 19.4 are assigned to

chemical and physical investigations to improve products and 7.0 to technology--process and product developments. In addition, the Division sponsors six research grants under Public Law 480.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 0.9 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical and Physical Investigations to Improve Products

1. Improved Ease-of-care Properties Through Fiber Modification. We are conducting research to provide basic information on the mechanical and physical properties of fibers, fiber assemblages, and fabrics and to determine the effects on these properties of treatments developed to improve fabric performance. We have found that appraisal of wool-cellulosic blend fabrics and garments treated for wash-wear performance requires wear tests in addition to laboratory testing. Felting shrinkage is completely controllable with interfacial polymerization (WURLAN I) and phase-boundary-limited crosslinking (WURLAN II) treatments. We are testing a new device for the appraisal of fuzz on fabrics. Physical property and wash performance data for many control and treated fabrics await correlation with wear trials. An interlaboratory test of an improvement in strength testing of wool fiber bundles was conducted for the American Society for Testing and Materials and Method 2524 was revised to include the use of a standardizing wool. Also, we have improved the technique for testing wool yarn abrasion.

The application of high-energy radiation to initiate grafting of polymers onto wool fibers is being studied under contract at the Research Triangle Institute, Durham, North Carolina. Rates of grafting and molecular weights of the polymer side chains grafted in situ have been determined for mutual and pre-irradiation grafting systems. Formic acid enormously increases the yields of grafting in wool. Pre-irradiation grafts have much shorter chain lengths than the corresponding mutual products. Measurements have revealed that, with pre-irradiation grafting, the free radical population levels off at a lower value with lower dose rates, and as expected, the population contains much more of the more stable radical species at the lower dose rates. Electron microscopy and small-angle X-ray scattering have helped to locate the grafted polymer in cell walls and inside the cell structures.

Stress-strain measurements on wool fibers modified by different polymers show that only minor changes in properties result from in situ grafting of as much as 20% of the polymers.

In order to predict and interpret the value of natural and modified fibers, we are studying the relationships of structure, composition and properties. We have written computer programs to process data on the amino acid composition

of wool proteins and peptides and also to calculate molecular weight distribution from ultracentrifugal sedimentation data. Wool is half soluble in aqueous reducing media at pH 2.6. The soluble part has a molecular weight mostly over 10,000 and when sedimented free from salts forms a gel which has an ultrastructure of uniform rods resembling wool microfibrils.

Structure development in wool is best explained by electrostatic stabilization from alternating isoelectric-point regions. Electrostatic forces can also greatly affect the kinetics of diffusion-controlled aggregation. Changes in mechanical properties accompanying wool swelling are anisotropic. Direct observation of swelling anisotropy in various parts of wool fibers is in progress. We are conducting research to develop continuous processes to bleach, improve dyeing properties and tensile strength, and produce durable shrink resistance in wool top, yarn and fabric. A wool-top drafting attachment has been incorporated in the corona discharge equipment to provide a thin webbing of wool fibers for continuous treatment in the corona reactor. Electrostatic fiber attraction to the electrodes is avoided by a conveyor belt made of Teflon-covered rods at appropriate spacing. Temperature is thermostatically controlled. Optimum temperature for treatment is 92-105° C. Chlorine gas in the electrical discharge regions markedly promotes the shrink-resist reaction. It is mixed with air and injected through holes in one electrode. Reactivity increases with the frequency of the corona electric field. Pretreatment of wool with dilute solutions of some metal salts, followed by drying, improves shrink resistance. With control of moisture content, electrical voltage, and accelerators, highly promising results were obtained.

We studied the effect of radiant energy upon wool fibers, with particular emphasis upon those parts of the spectrum to which wool is normally subjected. Among our important findings was a photophysical phenomenon which we called "Spectral Conformity." This appears to be a newly-recognized process by which a molecule dissipates absorbed radiant energy--without undergoing major chemical change. A curious consequence of this effect is that wool and many other materials--rubber, plastics, paper, cotton, silk, nylon, etc., become permanently bluer in blue light, for example. Our studies showed that yellowing of wool occurs in the ultraviolet region, whereas bleaching occurs in the visible spectrum, and the net effect will depend upon the spectral distribution of the radiating source, electrical or sunlight. The net effect of sunlight depends upon time of day, season, latitude, altitude, and atmospheric transmission, and thus varies with place and time. Of particular interest was the spectral transition region, in which yellowing and bleaching are caused simultaneously by a given wavelength, about 365 mμ. Of considerable theoretical interest was the greening of wool at 254 mμ. This was shown to be due to the simultaneous production of two independent absorbers, one absorbing blue light and the other, orange light.

Supported by P.L. 480 funds, the University of Allahabad in India is studying the interactions of organic molecules within wool fibers. In glycerol-water

solutions, sound absorption is maximum at 14 mole-percent observed at a frequency of 0.5 megacycles/second, and at 50 mole-percent at 0.8 megacycles/second. These results indicate that complexes form between water and glycerol, and suggest a possible new approach to the study of interactions in solution complexes with mole ratios of 1:6 and 1:1 (glycerol:water).

The Ahmedabad Textile Industries Research Association in India, supported by P.L. 480 funds is making measurements of the adsorption energy of selected ions to wool in order to determine the accessibility of ion exchange sites as loci for chemical modification. Analytic techniques for determining sodium, chloride and phosphate ions have been adapted to the determination of these ions adsorbed to wool and used to investigate extent of the adsorption of such ions to natural wool from 0.05 molar solutions of sodium chloride and trisodium phosphase at 50° C. The results are in accordance with non-specific binding to the wool protein which acts as an ion exchanger.

P.L. 480 funds are supporting a third research project in India. The Indian Institute of Technology in Kanpur, India, has begun a study to explain the mechanical behavior and structure of fibers as a function of molecular configuration.

The German Wool Research Institute in Aachen, West Germany, is supported by P.L. 480 funds to correlate chemical and physical properties of fine, coarse, and chemically modified wools with X-ray diffraction measurements. Specific staining of lysine in wool fibers is possible. Low-angle X-ray diffraction showed an axial periodicity of 39 Å for lysine residues in the structural units of mohair, and a distribution of these residues on the periphery of protofibrils. Results with Lincoln wool were similar. In contrast to earlier interpretations, evidence was found for microfibrillar swelling in alpha keratin fibers. The helices of the matrix are ordered in fiber direction, and their lateral spacings do not increase during swelling in water. Inter-microfibrillar spacing varies with the type of fiber. A quantitative correlation between crystallinity and mechanical properties was demonstrated with different types of alpaca.

Research to determine the sulfur distribution within wool keratin and its relation to the dimensions and aggregation of fibrillar components is being conducted at the Karolinska Institutet in Stockholm, Sweden, supported by P.L. 480 funds.

2. Improved Ease-of-care Properties Through New Finishing Treatments.

To improve wool's competitive position with easy-care synthetics, we are screening potential treatments for making wool fabrics resistant to shrinking, soiling, wrinkling, pilling, yellowing, and abrasion. Cross-linking wool in fabric form by reaction with sebacoyl chloride, one of the WURLAN reactants, did not result in durable press performance; wrinkling was worse after machine washing and tumble drying. A study was also made

of crosslinking reactions initiated in wool protein in solution with peroxydisulfate. Steric effects influence the reaction rate of persulfate with model peptides. The main attack is on the peptide alpha-carbon. Riboflavin-sensitized photopolymerizations of acrylic monomers proceed in the presence of proteins, amino acids, or peptides; the reaction depends on concentration and chemical nature of both monomer and protein. Wool treated with epoxides and then given the dihydroxy-dimethylolethyleneurea (DHDMEU) treatment, effective for durable press in cotton, showed only slight crease retention. DHDMEU caused wool to yellow on heating and reduced its abrasion resistance but did not reduce the fabric breaking strength or affect supercontraction. Novel dyeing of wool was achieved by coupling diazonium salts with wool. Also, with conventional dyes, a higher rate and better levelness of dyeing were obtained in wool pretreated with ethanolamine sulfite. New water and oil-repellent finishes derived from copolymerization of fluoroalkyl silanes and alkyl halosilanes are highly effective. Several new compounds were synthesized.

Contract research is being conducted by Harris Research Laboratories, Washington, D.C., to obtain basic data on low-cost protective finishes for wool and mohair. Polymers of 1, 1-dihydroperfluorooctyl acrylate (PFOA) and 1-(perfluorooctanoyl) aziridine (PFOAz) were prepared. The critical surface tension of wetting (CST) of PFOA was 10.3 dynes/cm. CST of PFOAz on wool fibers was less than 16 dynes/cm. Solutions of PFOA were prepared with five non-fluorinated extenders: poly(vinyl stearate), poly(stearyl acrylate), polyethylene, a polyamide, and a polyurethane. The critical surface tensions of wetting of PFOA-poly(vinyl stearate) mixtures were determined both by contact angle measurements and by observing whether coated fine glass rods float or sink on each member of a series of alkanes. By the contact angle method, 4% PFOA in poly(vinyl stearate) produced a CST of 15.7 dynes/cm., 7 dynes/cm. less than that of poly(vinyl stearate). By the coated rod technique, much less PFOA was needed to obtain a similar reduction in CST. This difference may be related to phase separation of the two polymers as the solvents evaporate. Since a very small amount of fluoropolymer can be extended with a great amount of relatively low-cost non-fluorinated material to produce a protective finish with low critical surface energy, highly effective, low-cost protective finishes for fabrics may be possible.

We are conducting research to improve and expand the use of interfacial polymerization (WURLAN I) and phase-boundary-limited crosslinking (WURLAN II) for wool textile finishing. The WURLAN I process for shrink-resist treatment of wool fabric has been improved by using an aromatic petroleum solvent. Advantages include better shrinkproofing, handle, reactant stability, and dyeability, lower cost, and simpler process control. Wool top has been treated effectively without using a strong alkali, and results are promising for blanket and wool knit material.

Studies of WURLAN II have focused on interfacial application of low-cost reactive isocyanate prepolymers. Although hand and wool stabilization

are excellent, reactant stability is unacceptable. Alternative reactants are being studied.

Contract research to determine the effect of selected chemical treatments on the luster of wool fabrics has been concluded. In connection with measurement of luster of wool fibers and fabrics, the investigators, Harris Research Laboratories, Inc., Washington, D.C., examined the properties of the wool fiber itself to determine the factors which influence the reflection or scattering of light from wool. The most significant factors were crimp and scale structure. For the precise measurement of luster, a method was developed for accurately measuring light reflected from wool, either single fibers or fabrics.

Methods for increasing the luster of wool fabrics were compared. Where luster arises from oriented pile fibers, as in velour coating fabrics, the luster can be increased and made more durable by light interfacial polymerization treatments, or by reduction and setting by monoethanolamine sulphite. When luster depends on the surface properties of the fibers, as in clear finish worsteds, some of the oxidative or subtractive antifelting treatments also add to luster. Chlorination by gas, or acid hypochlorite treatments, are the most favorable. Adverse effects on hand limit these treatments. Other oxidative shrink proofing treatments show less improvement in luster, or even lower it.

The Institute for Fibres and Forest Products Research in Jerusalem, Israel, supported by P.L. 480 funds, is conducting research to relate fiber crimp to chemical, physical, and mechanical properties of wool and determine the effects of processing on crimp. A method for defining and measuring crimp was applied to wool fibers. A computer program was developed to provide statistical evaluations and correlations between crimp parameters and mechanical properties of wool. Three types of wool were measured and crimp parameters obtained for a series of loadings on each fiber. The three wool types can be graded according to their crimp diameters, wave numbers, and uncrimping energies. Effects of water on dynamic crimp parameters and on Young's modulus were measured. An assumption is made that hydrogen bonds involved in crimping are weakened in water.

B. Technology--Process and Product Development

1. Improved Mechanical Knitting Technology. We are studying methods for spinning shrink-resist-treated top and for weaving or knitting the yarn into washable apparel. Studies of dimensional properties have shown that all knitted constructions can be dimensionally specified by parameters similar to those developed for the plain knitted structure, if the "structural knit-cell" is defined. This suggests that the configuration in space of the knit-cell is a geometrically determinate form which is independent of fabric construction. For the parameters to apply, the fabric must be in a state of minimum internal energy, which is achieved only after wet mechanical agitation. Even then, the dimensional

parameters are not strictly constant but depend on the ratio of loop length to yarn diameter. For plain knitted structures in a fully relaxed state, a fabric thickness has been defined by a dimensional parameter which is independent of loop length and proportional to yarn diameter. The degree of fabric compactness is highly dependent on loop length, and less dependent on the state of relaxation.

2. New Yarns and Fabrics of Wool and Mohair Combined with Other Fibers.

We are conducting research to develop blends with optimum functional properties, and processing and finishing procedures for them. Worsted fabrics of blended wool and cotton (50/50, 60/40, 70/30, 80/20) were produced, WURLAN shrink-resist treated, processed by delayed-cure cellulosic crosslinking and evaluated for durable press performance. WURLAN treatment of top before blending produced a more acceptable handle than treatment of the blend fabric. For satisfactory durable press, at least 40% cotton is required. Strength and abrasion resistance of resultant durable press-treated fabric are marginal, particularly in a light-weight fabric. Woolen system tri-blend fabrics of wool/cotton/nylon and wool/high wet modulus rayon/nylon (50/40/10 and 65/25/10) were manufactured, and durable press performance was evaluated. Both blend levels containing rayon produced satisfactory durable press garments, whereas with the blends containing cotton at least 40% cellulosic was required. A minor amount of nylon raised the strength and abrasion resistance to acceptable levels. These results define the maximum wool content consistent with adequate durable press performance. Durable press garments containing wool will be marketed in the near future.

We have completed a project to find new approaches for the chemical and physical modification of coarser wools as a basis for development of improved yarns and fabrics that would increase markets. Significant accomplishments include an improved procedure for shrink-proofing wool fabric with ozone, a novel electrical discharge method for continuous treatment of wool in webbing form, and a new method for making high stretch yarn.

The reaction of wool with ozone has been extensively investigated in terms of antifelting and bleaching effects. The reaction rate of ozone with wool can be increased by mixing steam with the ozone and passing the mixture through, rather than over, the wool. Although this method shortened the required reaction time, ozone consumption proved excessive, and the wool was seriously degraded.

High reaction rate with minimum wool damage and lower ozone consumption can be achieved by passing the dry ozone gas over fabric with a controlled moisture regain of 30 - 40%. This moist wool-ozone reaction can be further improved by increasing the surface velocity of the gas stream over the fabric with simultaneous contact heating of the underside of the fabric.

All wool stretch yarn has been produced by a twist, set, untwist procedure. Setting of the coiled configuration has been achieved by various resin treatments. The most promising resin setting procedures involve application by interfacial polymerization or phase boundary crosslinking techniques and solvent application of a reactive polyolefin. These methods impart a helical form to yarns producing an elastic property which is permanent to repeated load cycling and to repeated wetting and drying. However, the permanence of the stretch is lost by exposure to prolonged boiling. Recent investigations of combined heat setting (with water at 240° F.) and resin setting has produced yarns which retain stretch properties after prolonged boiling in water.

Further developmental studies of these promising new techniques for imparting desired improved functional effects on wool yarn and fabrics are under way. These investigations include design of experimental processing equipment for continuous treatment of carded webbing, top, yarn and fabric.

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POULTRY UTILIZATION - FOOD

Western Utilization Research and Development Division, ARS

Problem. The present technological problems in the utilization of poultry meat have grown from the profound changes in the poultry industry since World War II, which were unprecedented and are unequalled among the other agricultural industries. Per capita consumption of chicken and turkey meat has risen from 22 to 44 lbs.; the form of retail products has changed from messy uneviscerated poultry to tempting ready-to-cook or ready-to warm-and-serve items; the scale of individual commercial operations has expanded 10 to 20 fold; and vertical integration has linked breeder, hatchery, producer, and processor into vast economic aggregates. The only factor that has remained unchanged is retail price of the products, which in some cases has decreased even in the face of general wide inflationary trends. This price situation, with narrow profit margins, emphasizes the extremely competitive nature of the poultry industry. These changes have required, and will continue to demand, research to support the development of new, more efficient processes and new, more convenient and appealing products. The trend toward increased consumption of poultry should be encouraged, because poultry meat products represent a nutritious high-protein, low-fat food that is universally acceptable. Poultry is an efficient converter of feed to meat, which is low in cost relative to other meats.

The highly competitive situation in the poultry industry has accelerated further processing in order to build profits into the products. Technical problems consequent to this trend relate to the development of more efficient processing methods, retention of optimum flavor, tenderness, juiciness, and color of the products, and assurance of wholesomeness and safety. Plant processing rates of 10,000 birds per hour call for continuous automated operations, with elimination of discontinuous batch systems such as the presently required prolonged aging of birds in tanks of slush ice for adequate tenderization. Cutting the whole eviscerated birds into marketable parts has resulted in surpluses of backs and necks, which has created need for efficient methods of deboning and of utilizing the deboned meat in new products. For expanding sale of non-refrigerated products in domestic and foreign markets, there is need for improved methods of processing and maintaining quality in products that can be stored at ambient temperatures, such as dried, canned, cured, and irradiated poultry meat products.

Wholesomeness, particularly freedom from Salmonella, has become increasingly important as more poultry is processed into precooked forms that only require rewarming to serve. There is need to develop better sanitation in processing and to develop and incorporate pasteurization steps for some products so as to insure a completely safe product as the consumer receives it. To make the technological developments that can be used to build-in the values such as those mentioned, further knowledge is required on the chemical nature of poultry flavor and flavor changes during processing and storage, on

the post mortem chemical and physical changes in the poultry muscle that relate to tenderness, cohesiveness and juiciness of the meat, and on the controlled use of physical and chemical agents to pasteurize poultry meat products without seriously lowering their acceptability as foods.

USDA AND COOPERATIVE PROGRAMS

Basic and applied research on poultry meat and poultry meat products are conducted at the Division headquarters at Albany, California, and by contract in Madison, Wisconsin, Lincoln, Nebraska, and Berkeley, California. Fundamental studies on poultry flavor are concerned with the identification of flavor precursors in poultry meat and the isolation and identification of volatile flavor components developed during cooking. The chemistry of muscle protein and post mortem chemical changes are investigated relative to tenderness and other quality characteristics of poultry. The applied research is conducted on the stability of cold-tolerant microorganisms; special problems of flavor, texture and stability of precooked frozen foods; processing factors that influence tenderness of poultry meat; and maintenance of wholesomeness in poultry meat products.

The Federal program of research in this area totals 10.5 scientist man-years, including contract research. Of this number 3.5 are assigned to flavor; 3.9 to color, texture and other quality factors; and 3.1 to technology--process and product development.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 25.0 scientist man-years is devoted to research on new and improved poultry and egg products.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Flavor

1. Poultry Products with Improved Flavor. Two relatively new experimental approaches have proven to be valuable in studies of the constituents and precursors of cooked poultry aroma. In one, aroma from heated tissue is concentrated by trapping in a U-tube containing absorbent at a low temperature. The volatiles are then fractionated in a gas-liquid chromatograph that permits simultaneous detection of material by flame ionization and by smelling of the fractions. Although the chromatogram is quite complex, since all products from high temperature breakdown of fats, proteins, and sugars are possible, identifications of compounds thus far completed indicate that we will be able to identify many of the reactions that occur during heating of the tissue.

A second approach consists of the fractionation by differential absorption, with solid absorbents or solutions, of aroma laden nitrogen gas and identification of the predominant aroma components by a subjective odor panel.

Fractions containing a relatively small, e.g. 6 to 8, number of components are subsequently eluted from the absorbents by heat and fractionated on a gas-liquid chromatograph. By this method of separation and subjective evaluation of the aroma components at the concentration at which they exist in the total aroma, unequivocal proof of the importance of hydrogen sulfide, ammonia or ammoniacal amines, and an unidentified but characteristic fraction has been obtained. Further, by fractionation of the potential precursors of aroma and then development of aroma from these fractions, it has been established that up to 212° F. poultry fat by itself is not a precursor of any aroma constituent. However, it performs an important function in serving as a reservoir and a blending medium for the aroma constituents developed from the other muscle constituents. The sarcoplasmic fraction of the muscle was found to contain the essential aroma precursors.

A recently initiated study is designed to determine how amines may act as synergists to antioxidants in the stabilization of fat-containing poultry meat products.

B. Color, Texture and Other Quality Factors

1. Better Quality in Poultry Meat by Control of Post Mortem Muscle Reactions.

In order to make rational technological approaches to the retention of optimum texture (tenderness, cohesiveness, and juiciness) in processed and cooked poultry meat products, it is necessary to understand what effect processing conditions have on the ultimate structural elements of the meat. Toward this end, contract studies at the American Foundation for Biological Research, Madison, Wisconsin, are underway with the objective of relating processing-induced changes in the structural elements of the muscle, observed at the electron microscopic level, with changes in the quality factors, tenderness and juiciness. Studies were made of the effects of heat, freezing and thawing before aging, beating (as with a feather-picking machine), and electrical stimulation on muscle that was free to contract or that was held under restraint. Electrical stimulation caused contraction to 70% of the original length, thaw rigor 40%, and heating or beating plus heating 50%. Much greater loss of the ultimate structural elements of the muscle was observed for muscles treated and allowed to contract than for those treated in restraint. Local contraction was noted in muscle heated under restraint, resulting in a stretching and tearing of the filamentary structure in adjacent areas.

In studies of fundamental changes in the muscle proteins that are related to tenderization during aging, it has been confirmed that collagen does not change. In breast muscle, a marked decrease occurred in the 6-24 hour post mortem period in extractable myosin, and correspondingly an increase in actomyosin extractability. This may be due to release of actin from the bound state, possibly involving breakage of bonds with tropomyosin at the Z line (i.e. junction of two sarcomeres or recurring structural units). Amounts of sarcoplasmic fraction (soluble in dilute

salt solution) and nonprotein nitrogen did not change significantly in 24 hours post mortem.

In order to have a basis for comparison of objective shear force measurements from different sized muscles or muscle slices, the relation of shear force to cross sectional area of the sheared muscle specimen was determined. Shear force was not proportional to the area as some people assume, but to approximately the 0.6th power of the area. Force thus increases more nearly in proportion to increase in a linear dimension, such as the diameter. This should have significance in explaining the basic nature of the forces resisting shearing or biting action.

C. Technology--Process and Product Development

1. Better Freeze-Dried Poultry Meat. We have developed an objective method to measure the cohesiveness in freeze-dried and other poultry meats. Uniform cylinders of cooked muscle are cemented between circular metal plates and pulled apart in a tensile tester; the force and work required to separate the fibers are recorded. The work (force times distance) is inversely correlated with cooking time, and directly correlated with undegraded collagen, the protein which binds muscle fibers together. The work required to separate fibers is significantly less for freeze-dried meat than for frozen meats. Loss of cohesiveness is due to changes that occur in the later stages of drying - when moisture is below 30%.

The design of continuous freeze-drying equipment is investigated to help develop economical, stable, dehydrated poultry meat and to improve drying apparatuses. One result of this study is a rotating vacuum freeze drier designed for the continuous freeze-drying of small particle sized foods. A contract to acquire engineering data needed for economical freeze-drying of poultry meat was placed with the University of California, Berkeley. Thermal conductivity, pore size, bulk diffusivity and rate-limiting factors have been determined. Measurements support a mathematical model of a uniformly retreating ice front for 80% of the drying cycle. Thermal conductivity can be calculated from observed drying rates. If the pressure is cycled with helium between 1 and 10 mm. of mercury, thermal conductivity of the dry material is momentarily improved by convective heat transfer of the gas space within the piece, and the temperature of the ice core is kept low by rapidly reducing the pressure before melting occurs. By using low-density gas, good heat-transfer is provided without mass-transfer inhibition. We tested this idea by flowing a stream of low-pressure gas through the drying bed and a condenser, across a heater, through a desiccant, and back into the drying sample.

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EGG UTILIZATION - FOOD

Western Utilization Research and Development Division, ARS

Problem. Between 1956 and 1966 egg production increased from 61 to 66 billion eggs, but per capita consumption decreased to 85% of the 1956 value. The decrease in per capita consumption reflects a decrease in table egg use. The per capita use of egg products, eggs removed from the shell and further processed is estimated to have increased during the past decade. Egg product use amounts to about 10% of the total consumption. The increase in egg product use and the consumer demand for convenience foods indicate that further efforts to increase egg product consumption will help to reverse the downward per capita trend of egg consumption.

Processing and preservation frequently alter the useful properties of eggs so that they have a reduced value for their many essential uses in baked and other prepared products. The foaming, coagulating, emulsifying and flavor properties that make eggs so valuable in bakery products must be retained in eggs that are preserved in stable forms such as frozen and dehydrated products. Therefore, the long-term objective of egg product research is to preserve and enhance at minimum cost the foaming, coagulating, emulsifying, and binding properties of eggs that make them uniquely useful in cakes, custards, puddings, souffles, omelets, meringues, pies, pancakes and other foods. The properties vary with processing treatments such as freezing, drying, homogenization, and pasteurization and also with storage. The variations are due to variable changes in one or more of the 20 plus major components of eggs. Important components include glycoproteins, lipoproteins, unconjugated proteins, free lipids, glucose, and enzymes. Interactions occur between components. Individual components exhibit damage or change in processing. Knowledge of both the properties of individual components and their interactions is needed to maximize the value of egg products in convenient and attractive forms for the consumer and therefore to increase the return available to the egg industry.

USDA AND COOPERATIVE PROGRAMS

In the Western Utilization Research and Development Division, a broad program of basic and applied research is conducted at the Division headquarters at Albany, California; by contracts and grants in Ames, Iowa, Ithaca, New York, Jefferson City, Missouri, and Davis, California; and by grant funds under P.L. 480 in India. Fundamental research is conducted on egg proteins and their relations to the functional properties and quality of eggs, on egg lipids and lipoproteins and other components of eggs. At present applied research concerns primarily the occurrence of Salmonella in eggs and egg products, methods of destroying Salmonella, and the effect of pasteurizing methods on the usefulness of egg products. Past and continuing objectives include the stabilization of yolk-containing solids for use in mixes and other convenience foods, the development of more readily

dispersible dry products, and the development of useful information on the effect of other food components (sugar, salt, whipping aids, etc.) on the properties of egg products of all types.

The Federal program of research in this area totals 12.3 scientist man-years, including contracts and grants. Of this number 4.0 are assigned to chemical composition and physical properties; and 8.3 to microbiology and toxicology. In addition, one research grant is supported by P.L. 480 funds.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 25.0 scientist man-years is devoted to research on new and improved poultry and egg products.

A. Chemical Composition and Physical Properties

1. Improved Egg Products. We are studying the physical and chemical properties of those proteins and other egg components that affect or possibly influence the functional properties of egg products. The proteins currently being investigated are ovomucin, flavoprotein, "line 18," ovoinhibitor, and the globulins of egg white.

The proteinase inhibitor activity (ovoinhibitor) of egg white was found to consist of at least three components. Their properties are being studied. We have purified the globulin, "line 18" and begun a study of its physical properties. The fractionation procedures developed led to recognition of GDP-mannose and UDP-N-acetylgalactosamine sulfate as the principal nucleotides of egg white. A UTP-diphosphahydrolase was found in egg white.

Damage to whipping properties of egg white caused by pasteurization is partially due to heat denaturation of the lysozyme-ovomucin electrostatic complex. The rate of reaction increases with pH and is proportional to the ovomucin and lysozyme concentration. The product, a denatured aggregate, decreases the mechanical stability of egg white foams.

Ultraviolet absorption and fluorescence studies of ovomucoid give strong circumstantial evidence for intramolecular tyrosylcarboxylate ion hydrogen bonds. Ovomucoid has an expandable crevice which allows the entrance of a water molecule but not a methanol molecule at pH 3, but both are admitted at pH 7.

Contract research is underway at the Iowa State University in Ames to develop new and better products by altering the functional properties of egg white. The effects of treating egg white with oxidative reagents, coordinate bond reagents, and by acylation were determined. Treating egg white with oxidative reagents did not produce any new properties of commercial interest. However, the changes produced by hydrogen

peroxide will be investigated further because of its use in egg white pasteurization. Angel cake prepared from acylated egg whites were of poor quality. Coordinate bond reagents changed the electrophoretic properties of egg white when the concentrations were much greater than those used to improve whipping rate.

The Lincoln University in Jefferson City, Missouri, recently was awarded a grant to characterize the binding properties of ovomucin and lysozyme, an interaction that affects the whipping properties of heat-treated egg white as already indicated.

Supported by P.L. 480 funds, the Indian Institute of Science in Bangalore, India, is conducting research to determine the physico-chemical nature of changes in egg yolk components caused by freezing and thawing. The "gelled" and "soluble" protein fractions of yolk are both glycoproteins containing hexose, hexose amine, and sialic acid. The soluble fraction contains about 50% more sialic acid, which may account for its non-gelling characteristic. The effect of adding pepsin to egg yolk before freezing is being evaluated. Conditions were found under which the thawed product passed quickly through the "gelled" stage to the consistency of native yolk.

Basic investigations of lysozyme from eggs and other animal sources have been concluded at the University of Paris, France. Supported by P.L. 480 funds, this project completed the determination of the chemical structure of hen's egg white lysozyme which paved the way for a study of the relative importance of some of the amino acids and their sequences as they affect biological activity. Research was conducted to determine whether or not lysozymes from different sources exhibited different biological properties and whether or not they had different chemical structures. Results indicate that lysozymes extracted from the same organ, but from different animal species, are different, lysozymes extracted from different organs of the same animal can have either different or identical properties, and more than one lysozyme can be extracted from the same secretion.

Research supported by P.L. 480 funds at the Commonwealth Scientific and Industrial Research Organization in Ryde, Australia, has been concluded. The research concerned a unique change in ovalbumin that occurs at alkaline pH (8 to 10) and mild temperature conditions (about 50° C.). Exposure converts ovalbumin to a more heat stable form. This is of both fundamental and practical importance. Comprehensive studies of the phenomenon were undertaken. The possibility that the phenomenon is due to an interchange between an S-S bond and one of the SH bonds of ovalbumin was shown not to be the case.

B. Microbiology and Toxicology

1. Control of Salmonella in Liquid and Dried Eggs. We are conducting research to develop practical, reliable methods for Salmonella destruction in processing liquid and dried egg. A survey of the heat resistance of

300 strains of Salmonella has uncovered only one strain other than the well-known S. senftenberg 775W which has relatively high heat resistance. S. blockley 2004 has 5 times the heat resistance of S. typhimurium TM-1 and S. senftenberg 775W has about 25 times the resistance. The results of our surveys of the numbers of Salmonella in raw commercial egg products (generally less than 1 per ml.) assure that a high margin of safety is achieved in pasteurized egg products, since present pasteurization conditions are designed to kill much larger numbers. Also, since Salmonella of high heat resistance are extremely rare, the occasional detection of viable Salmonella in pasteurized dried egg products seems most likely to be the result of post-pasteurization contamination.

Our studies designed to determine why S. senftenberg 775W is much more heat resistant than other Salmonella strains have shown that S. senftenberg 775W responds in the same manner as a strain of normal heat resistance to various cultural and environmental conditions. Stationary-phase cells are more resistant than log-phase cells, growth medium is without significant effect, and growth temperatures have comparable effects on both strains.

The wide range of egg products which must now be pasteurized complicates the problem of specifying conditions that will provide equal heat treatment for all without damage to their functional properties. Additives such as sugar and salt, useful in decreasing gelation in frozen yolk-containing products, alter the viscosity of the product and thus the flow rate through the pasteurizer. Since the flow rate of egg products does not correspond to an ideal system in which the degree of turbulent and laminar flow can be calculated, we have developed two methods for measuring residence time of egg products in holding tubes. These have been found reliable in plant tests; and in most pasteurization operations, the fastest-moving portion of the egg remains in the holding tube from 0.6 to 0.8 of the average residence time. The results have been used to determine the time and temperature conditions required to give adequate heat treatment to the various egg products being pasteurized.

The addition of salt or sugar increases the heat resistance of Salmonella in egg products, but the addition of acetic acid reduces the heat resistance of yolks containing either salt or sugar. Since acetic acid (vinegar) is normally used in the manufacture of mayonnaise or salad dressing we have determined the reduction in pasteurization temperature that will produce Salmonella destruction in the acidified product equal to that at a higher temperature in the usual salt and sugar yolk. If current tests on performance of acidified pasteurized salt and sugar yolk show no alteration from normal, addition of acid to these products before pasteurization will make possible significant lowering of current pasteurization temperature requirements.

A manual has been prepared to help the egg industry supply Salmonella-free products to all users and is now being reviewed for early release. It describes treatments needed to destroy Salmonella in all products and

attempts to explain why they are necessary. It contains information about the physical and chemical properties of eggs, the microbiological factors involved in pasteurization, the accepted methods of pasteurization, and a description of desirable plant lay-out and operating guidelines. The manual will be useful as an aid in training plant personnel and in helping to coordinate the regulations for pasteurization of egg products being issued by U.S.D.A., state, and local governments.

A research grant was made to Cornell University in Ithaca, New York, to develop selective sensitive methods for determining Salmonella in egg products by studying the biochemical mechanisms of their growth on selenite-enriched media. In addition to basic information developed, it was found that modification of the differential selenite medium currently in use by increasing selenite concentration from 0.4% to 3% increased recoveries of Salmonella from samples containing low levels of contamination.

Contract research is being conducted at the University of California in Davis to evaluate potential chemical pasteurization treatments by determining the changes they cause in major and minor components of eggs. Changes in proteins and/or lipids were generally observed for all agents used. The practical significance of observed changes will be determined. Effects observed include the following: Salicylaldehyde modifies the amino groups of albumin; dialysis of the modified albumin against deionized water reverses the action. Spectral and other characteristics of the model systems, glycine and butylamine, are similar to those for salicylaldehyde reacting with serum albumin. Studies of the effect of hydrogen peroxide on yolk lipids were conducted because of a proposal to use hydrogen peroxide to pasteurize whole eggs. Under the pasteurizing conditions specified, hydrogen peroxide reacted with the phospholipid but not with the triglyceride fraction of egg lipid. The chemical change in the phospholipid has not been identified, but the stability of the phospholipid fraction to oxidative deterioration at 20° C. was decreased more than 20%. The effect of peroxide on yolk products will be studied further.

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Re-examination of heat resistance of Salmonella typhimurium in ground chicken. Henry G. Bayne

Heat sensitivity of 300 Salmonella isolates. Henry Ng

Sensitivity of Salmonellae to beta and gamma energy. Hans Lineweaver

Sensitivity of Salmonellae to UV energy. Kosuke Ijichi

Engineering aspects of egg pasteurization. George W. Putnam

WRRL process for pasteurizing liquid egg white. F. E. Cunningham

III. MARKETING AND ECONOMIC RESEARCH

DAIRY PRODUCTS - MARKET QUALITY

Market Quality Research Division, ARS

Problem. Dairy products in marketing channels are subject to deterioration by microbiological action and oxidative processes. In addition, several kinds of insects and mites may contaminate or damage dairy products during storage and distribution. Improved tests for estimating initial quality and information on factors influencing keeping quality would be useful to minimize deterioration in marketing channels. Pasteurized milk invariably spoils within a week or two from bacterial growth in refrigerated storage. Information is required on the source of the spoilage organisms and on how they may be eliminated. Safe and effective methods of preventing or controlling insect and mite infestations are needed. More information is needed on the storage-life of butter and butteroil under various conditions and on the factors which predispose these products to deterioration. Contamination by pesticide residues continues to be a major problem. Simplified methods are needed for detecting such residues in dairy products and also in feeds to facilitate removal of excessively contaminated products from marketing channels.

Modern marketing practices in the dairy industry have intensified the problems of detecting inferior lots of milk and of increasing the storage-life of dairy products. Several kinds of insects and mites contaminate or damage dairy products during processing, storage and distribution. To maintain quality of these products in marketing channels, research is needed on the factors influencing keeping quality; on developing new and improved objective quality tests for bulk milk and other products; on developing safe and effective procedures for preventing or controlling insect and mite infestations; and to find improved and simplified detection methods for antibiotic and pesticide residues in dairy products.

USDA AND COOPERATIVE PROGRAM

There is a continuing program of basic and applied research aimed at developing new and improved methods for assessing the important quality factors in a variety of dairy products. At Beltsville, Maryland, studies are continuing on improved methods of analysis of feeds and forages for chlorinated pesticide residues (MQ 3-70). Arrangements have been made to obtain butter samples to make a study of the relation of moisture distribution to keeping quality of butter (MQ 3-57). A basic study of heat injury and recovery of bacteria was begun (MQ 3-93). The Federal scientific effort in the Field Crops and Animal Products Research Branch devoted to research in

this program totals 2.0 scientific man-years. The following projects were terminated during this period: Development of objective tests for predicting keeping quality of anhydrous butter (MQ 3-49) and Improved procedures for direct microscopic counting of bacteria in milk (MQ 3-76).

Another program formerly located at Fresno, California, was moved to Madison, Wisconsin, at the beginning of the reporting period. This program involves basic and applied entomological research directed toward the prevention of insect and mite infestation in dairy products. It is carried out in cooperation with the Wisconsin Agricultural Experiment Station. Much of the cross-commodity research reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dairy products.

A 3-year cooperative agreement (1966-1969) with the University of Wisconsin is concerned with the study of microbial symbionts in selected stored-product insects.

Under a 3-year cooperative agreement (1967-1970), the University of Wisconsin will study the effect of wall coatings on the residual toxicity of insecticides.

A grant to the Tokyo University of Agriculture, Tokyo, Japan, is for a 3-year study, part of which is on the constituents of dairy products that attract mites. It continues until August 1968 and involves P.L. 480 funds with a \$38,622 equivalent in Japanese yen.

The Federal effort in the Stored-Product Insects Research Branch on this program during the reporting period was 1.8 scientist man-years, of which 0.6 was on a contract and 0.2 on a cooperative agreement.

A 2-year research contract under Line Project MQ 1-32(C) with the Stanford Research Institute, Menlo Park, California, was concluded at the end of the reporting period. It achieved its objective to identify and synthesize the natural attractants in the black carpet beetle.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 16.5 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Moisture Distribution in Butter. Arrangements have been made to obtain samples of a number of lots of butter before and after printing to determine the effect of printing on moisture distribution and shelf-life. (MQ 3-57)

2. Chlorinated Pesticide Residues. It is difficult to clean up chlorine pesticide residues in livestock feeds for analysis. Single-step chromatographic procedures proved inadequate for preparing samples for analysis by thin-layer chromatography (TLC). A two-step procedure using successive columns of carbon-celite and partially inactivated Florisil proved very effective with all types of feeds encountered. The carbon-celite procedure was modified for preparing samples for both gas and thin-layer chromatography. Using a 1 g sample of feed, residues can be detected at 0.01 p.p.m. (MQ 3-70)

3. Direct Microscopic Counts. The study of correlations among four direct microscopic counting (DMC) procedures for milk was completed. The DMC stains used were: (a) the Levowitz-Weber methylene blue stain, (b) a modification of (a) incorporating basic fuchsin, (c) an alcohol-acetic acid fixation followed by a periodic acid-bisulfite-toluidine blue stain, (d) an alcohol-acetic acid fixation followed by staining with toluidine blue buffered to pH 4.0. Correlation was highest (0.968) between staining procedure (a) and (d) and lowest (0.854) between (b) and (c). The type of organism inoculated in milk influenced the correlations among the four procedures. The precision of DMC counting was shown to be independent of the staining procedure, but was significantly influenced by the number of microscopic fields counted. (MQ 3-76)

4. Heat Stability of Bacteria. A basic study of the problem of heat resistance and damage of bacteria which constitute the normal spoilage flora of pasteurized milk held at refrigeration temperature was initiated. On the basis of their heat resistance and their pattern of recovery, under the conditions of the experiment, bacteria were separated into various groups; those which will survive the heat treatment (30 minutes at 55° C.), those which will neither survive nor recover, those which will not survive but will recover after various lengths of time in the recovery medium. Preliminary results indicate that the presence of a complex medium (even in dilute concentration) during heat treatment as well as during recovery is necessary for bacteria to recover. (MQ 3-93)

B. Prevention of insect infestation

1. Biological Control. The sex-attractant produced by female black carpet beetles, Attagenus megatoma (formerly called piceus) has been isolated, identified, and synthesized. The compound is trans-3,cis-5-tetradecadienoic acid. Male beetles respond to the synthetic product in the same manner as they do to the females. A trap to be used with the attractant has been built and tested successfully in the laboratory. Large numbers of female Trogoderma inclusum and T. glabrum have been isolated and their sex-attractants are receiving preliminary study. (MQ 1-32(C))

The existence of a potent sex attractant produced by female cigarette beetles has been demonstrated. Experimental procedures developed in the study of the carpet beetle pheromone have been used in this study, with adaptations and additions where necessary. Mass rearing procedures were developed and large numbers of females have been isolated. Preliminary indications are that the attractant is relatively stable and can be stored in a deep freeze. Its volatility is such that both short-pass distillation and thin-layer chromatography can be applied. (Exploratory)

In a detailed anatomical and histological study of the alimentary canal of the carpet beetle Attagenus megatoma, ninety percent of the larvae examined were found to contain intestinal protozoans of the family Actinocephalidae. They are reported to be nonpathogenic but this point is not certain. Their association with the insect is receiving further attention. Preliminary studies were made on the isolation and identification of other micro-organisms associated with several species of dermestids, the Indian-meal moth, and the cigarette beetle. Antimicrobial feeding studies were conducted to develop aposymbiotic individuals and populations. Significant decreases in weight were noted in some tests where sorbic acid was used. (Cooperative Agreement, University of Wisconsin)

An attractant for the cheese mite has been separated from cheddar cheese by steam distillation. It can then be extracted from the distillate with ether and is found in the neutral fraction of the ether extract. (All-MQ-3(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement of Quality

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Prevention of Insect Infestation

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LIVESTOCK AND MEAT - MARKET QUALITY
Market Quality Research Division, ARS

Problem. To insure that grades are a true measure of palatability, a better understanding of the relationship between the physical and chemical properties of muscle and quality must be established. This information can then be used to devise objective methods for measuring the degree of tenderness, juiciness, and flavor in meat cuts.

The dominant method of merchandising meat in retail stores today is through the use of self-service display cases. Therefore, quality and appearance of the meat is of primary importance and research on maintaining meat quality and shelf-life is a necessity for the success of this type of merchandising. Lighting conditions required to evaluate meat quality need to be defined so that the meat quality attributes can be properly assessed.

The maintenance of desirable meat quality during various transport techniques and the determination and evaluation of the various methods of shipping fresh meats to European markets are primary research needs if we are to expand our market for fresh meats.

Wholesomeness of a meat carcass and maintenance of meat quality presupposes proper handling, slaughter and processing of disease-free animals that are not contaminated with toxic chemical residues. Development of rapid objective methods to detect unwholesome characteristics and deterioration of meat quality would aid the regulatory agency in their consumer protection efforts and would be useful to the meat industry.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists and food technologists in basic and applied research to maintain and improve the market quality of meat and to develop objective methods for quality evaluation. Studies are being carried out at Beltsville, Maryland, partly in cooperation with the Animal Husbandry Research Division and the Transportation & Facilities Research Division, ARS, the Livestock Division, Consumer & Marketing Service, the Radiological Laboratory of the Johns Hopkins Medical Institute, and under cooperative agreement or contract with the Universities of Florida, Illinois, Missouri, Oklahoma, Wisconsin and with Texas A&M.

The Federal scientific effort devoted to research in this area, exclusive of contract research totals 6.2 scientist man-years divided as follows: quality evaluation, 5.2, and quality maintenance, 1.0.

The following project was terminated during this period: "Objective methods for evaluating the market quality of livestock and meat." (MQ 3-34)

A PL 480 grant with the Research Center of the Meat Industry, Helsinki, Finland, provides for a study on the effects of carbon dioxide and nitrogen on chemical and physical properties of refrigerated meats. The project ran from 1963-67 and was extended to 1968 and involves \$57,524 equivalent in Finnmarks.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 19.1 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective Measurement and Evaluation of Quality

1. Objective Methods for Evaluating the Market Quality of Livestock and Meat.

Research conducted under a cooperative agreement with Texas A&M showed that freezing lamb leg roasts and loin chops resulted in a significant increase in shear force value and decrease in flavor score and taste panel acceptance.

Four hundred and sixty frozen stored meat cuts from Choice and Good carcass grade beef (A+ to B- and young A- maturities) and calf of Good carcass grade were evaluated at the University of Missouri and at Beltsville, Maryland. Relationships of palatability to carcass grade and maturity shown by whole meat cuts were generally opposite to those noted for ground meat samples. For whole meat cuts, there were minimal differences in odor and flavor of samples within Good carcass grade but Choice samples were generally more desirable. Differences in juiciness were observed only for inside round roasts with the highest juiciness associated with beef carcasses of A- maturity followed by calf. The highest tenderness scores of spencer roll steaks were associated with beef carcasses of A+ to B- maturities. (MQ 3-34)

2. Lighting Requirements for Evaluation of Meat Quality. Statistical analyses of data obtained from light studies showed: (1) color of meat samples illuminated with incandescent light was significantly more desirable (cherry-red) than the same samples evaluated under deluxe warm white or cool white fluorescent light; (2) samples evaluated at 50 foot-candles had a more desirable color rating than the same samples judged at 15 foot-candles; (3) a significant difference (5% level) existed between the incandescent and deluxe warm white fluorescent lights when evaluating degree of marbling; and (4) no significant difference was found between 15 and 50 foot-candles of illumination when judging degree of marbling. (MQ 3-59)

3. Relationship of Marbling to the Palatability of Beef. A study to determine the influence of marbling upon the tenderness and juiciness of beef differing in maturity was carried out under contract with the University of Wisconsin. Sixty carcasses were evaluated for shear and taste panel scores,

color by transmittance, pH by probe and homogenate, expressible juice, ether extractable material, extractable protein, sarcoplasmic protein, myofibrillar protein, sarcomere length, fiber diameter, muscle bundle size and fat distribution. Statistical analyses of the data are underway. (MQ 3-60(C))

4. Objective Measurements of Beef Maturity. Preliminary investigation of five muscles from 18 carcasses of beef ranging in age from 12-24 months, indicates a significant increase in concentrations of free amino acids occurs during post-mortem aging of the carcasses. Apparently, a high positive linear correlation exists between chronological age of the beef and phospholipid content of the muscles. Changes of triglycerides, free fatty acids, unsaponifiables, sarcomere length and tenderness are also being examined for relation to maturity and aging. (MQ 3-62)

5. Methods for Cutting and Thawing Frozen Meat. A survey of methods for excising meat inspection samples from blocks of imported frozen boneless meat was completed under contract. Band saws of at least 2 h. p. were better than the guillotine-type slicer or the circular saws tested. Hot water defrosting of the frozen meat samples proved more effective than hot air. Two-inch excised meat slices, placed in plastic bags and immersed in 125°F. water thawed in 25 minutes. Studies of dielectric and microwave energy thawing have been initiated under contract. (MQ 3-91(C)(Rev.))

B. Quality Maintenance in Handling, Packaging and Storage

1. Refrigerated Meats Stored in Atmospheres of Carbon Dioxide and Nitrogen.

Storage atmospheres containing 40% CO₂, 90% N₂ and 95% N₂ were investigated for their influence on (1) keeping quality of meat; (2) chemical changes; and (3) changes in microbial flora and numbers. The keeping time of meat stored in N₂ was 12 days whereas meat stored in 40% CO₂ was organoleptically acceptable for about 26 days.

Keeping time was greatly influenced by number of bacteria on the meat surface immediately after flaying. Numbers of bacteria on the surface and in the interior of meat stored in 40% CO₂ were considerably smaller than for the control (which was held in air at 0°C. and 95% relative humidity). Nitrogen storage of meat had little effect on bacterial counts. (E8-AMS-5(a))

C. Light Transmittance Techniques

Fat and moisture analysis of meat. The infrared absorption technique has also proven useful in indicating the fat and moisture content of processed meat. The difference in optical density between 1.80 and 1.725 microns gave a high correlation ($r = 0.977$) with moisture content and the difference between 1.725 and 1.65 microns gave a high correlation ($r = 0.974$) with fat content. These measurements were made on meat emulsions and included raw and cooked samples, as well as commercial samples. This direct spectrophotometric analysis predicted fat content within a standard error of $\pm 2.1\%$ and moisture content within $\pm 1.4\%$.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Berman, M. D., and A. W. Kotula. 1966. Relationship between age and haemoglobin-splitting activity in chicken muscle. Nature 210:(5042)1271-1272. (MQ 3-62)

Field, R. A., K. E. Hoke, J. D. Kemp, G. T. King, and J. L. McBee, Jr. 1966. Recommended procedures for lamb carcass evaluation. Section of proposed procedures for carcass evaluation and content. Published by the American Meat Science Association. (MQ 3-34)

Hornstein, I. 1966. Preface. Advances in Chemistry Series. Journal of American Chemical Society (56):VII-IX. (MQ 3-61)

Hornstein, I. 1967. Flavor of red meats. Chemistry and Physiology of Flavors. Avi Publishing Co., Westport, Connecticut, Chapter 10, 228-250. (MQ 3-61)

Hornstein, I., and R. Teranishi. 1967. The Chemistry of Flavor. Chemical and Engineering News 45:(15)92-108. (MQ 3-61)

Hornstein, I., P. F. Crowe, and J. B. Ruck. 1967. Separation of muscle lipids into classes by nonchromatographic techniques. Analytical Chemistry 39:352-354. (MQ 3-62)

Quality Maintenance in Handling, Packaging and Storage

Hoke, K. E. 1967. Effect of modified atmospheres on meat quality. Proceedings of the 21st Annual International Conference on Handling Perishable Agricultural Commodities. (E8-AMS-5(a))

WOOL AND MOHAIR - MARKET QUALITY
Market Quality Research Division, ARS

Problem. Wool fineness, variability, and color are the most important quality characteristics in determining the grade and consequently the economic value of wool. However, present methods of determining wool fineness and variability are slow and tedious and the causes of yellow coloration of raw wools are not known. Animal fibers in raw or manufactured form are subject to damage by several kinds of fabric insects, estimated to cause at least \$350 million loss annually. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information that can be used in developing better preventive treatments. The safety of several compounds now used for mothproofing wool has been questioned, and safer effective treatments are needed.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program for quality evaluation of wool involving (1) the study of the relationships of fineness, softness and quality of domestic wools; (2) development of rapid methods for the preparation of cored wool for determination of fineness and variability of fineness; and (3) determination of the causes and prevention of canary yellow coloration in raw wools. Work is in progress at Beltsville, Maryland, University of Wyoming, and Shri Ram Institute for Industrial Research, Delhi, India. The research in India is a 5-year program, 1963-68, being carried out under a P.L. 480 grant of \$92,536 equivalent in rupees. The Federal effort devoted to research in this area of quality evaluation is 1.1 scientist man-years of which 1.0 is on contract research.

There is also a continuing Department program headquartered at Savannah, Georgia, involving applied research in entomology and chemistry, directed toward the protection of wool, mohair, and other animal fibers against insect damage, with special emphasis on the development of nontoxic mothproofing treatments. The research is conducted in cooperation with the Armed Forces Pest Control Board and various industry groups.

A 2-year contract with the Harris Research Laboratories, effective in June 1966, is for research to develop commercial procedures for applying quaternary ammonium compounds as mothproofing treatments.

The Federal effort devoted to research on the protection of wool and mohair against insect damage was 1.6 scientist man-years, of which 0.6 was under research contract. Some of the cross-commodity research reported in

Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in wool and mohair.

Line Project MQ 1-49(C), a study of the physical and chemical factors affecting the sorption and retention of quaternary ammonium mothproofing compounds by wool, was terminated in April 1967 after completion of the contract.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 2.3 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Sample Preparation of Wool for Fineness Determination by the Coulter Counter Technique. A rapid method has been developed for the preparation of specimens of wool tops and grease wool cores for fineness analyses in the Coulter Counter. Grease wool core preparation includes detergent cleaning and scouring of the sample followed by hand carding. (MQ 3-69(C))

2. Interrelationships of Wool Fineness, Softness Quality and Market Evaluation of Domestic Wools. Objective methods for the evaluation of softness of bulk wool samples are being developed. One method showing promise is the measurement of the amount of work required to compress a pad of wool using a plate attached to an Instron Tensile Tester. Repeated compression/recovery cycles have indicated that compression loads in the range of 0 to 50 grams appear to yield the most precise estimate of softness. (MQ 3-92(C))

3. Canary Yellow Coloration of Raw Wool. Isolation and characterization of pigments from canary yellow stained wools have shown that pyrrole, amino, phenolic, carbonyl and unsaturated chemical groups are present. Test results on canary yellow stained fleeces showed that the yellow staining was much less severe in the United States wool than in wool from India. United States canary yellow stained fleeces have a higher grease content, higher suint content and a lower pigment content in the wool fibers than do Indian wools. (A7-AMS-12)

B. Prevention of insect infestation

1. Nontoxic Mothproofing Treatments. Of the 38 compounds given preliminary evaluation as mothproofers, 5 were found promising because of performance and low mammalian toxicity. Their oral LD₅₀ for rats ranges between 1,000 and 4,640 mg. per kg. (MQ 1-26)

The Eastern Utilization Research and Development Division worked out a method for tanning with gluteraldehyde the shearlings used for hospital bed pads. Since the gluteraldehyde combines chemically with the keratin in the wool and forms strong cross links, it was hoped the treatment might also provide mothproofing properties to the wool. Bioassay tests revealed that the treated wool was not protected against feeding by the black carpet beetle. (MQ 1-26)

Practical studies with a quaternary ammonium compound showed that this material could be applied in a home type washer to provide an effective mothproofing treatment. Application in a commercial type textile padder was not so effective, probably because there was mostly surface deposition rather than thorough impregnation of the fabric. Desorption studies conducted with radioactive forms of four quaternary ammonium compounds, conducted under selected laundering and drycleaning conditions, showed that all four were removed more readily by laundering with soap and detergents than by drycleaning. (MQ 1-49(C))

Studies with 23 compounds representing quaternary ammoniums with short or intermediate length alkyl chains, dimethyl benzyl lanolinamido ammonium chlorides, a pyridinium chloride, and several alkylamines, showed that a quaternary ammonium compound with eight-carbon alkyl chains was highly effective against both carpet beetles and clothes moths at deposits on wool of 12 to 30 times less than for other quaternary ammonium compounds previously tested. (MQ 1-61(C))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Buras, Jr., E. M., J. A. Penoyer, Sr., and K. E. Hoke. 1967. Cutting wool fibers for electronic particle size analysis. Proc. Fiber Society. Asheville, North Carolina. May (Abstract) (MQ 3-69(C))

Chipalkatti, H. R., A. D. Sule, K. K. Juneja, and M. C. Aggarwal. 1965. Some observations on canary coloration in Indian raw wools. Journal of the Textile Institute 56(12). (A7-AMS-12)

Chipalkatti, V. B., R. Chatterjee, and K. K. Juneja. 1966. The role of lanthionine cross links on tenacity of alkali-damaged canary-stained wools. Textile Research Journal 36(12). (A7-AMS-12)

Chipalkatti, V. B., A. D. Sule, and M. M. Bhan. 1966. A spectrophotometric method for determining the degree of redness of yellow wool samples. Textile Research Journal 36(12). (A7-AMS-12)

Ranganathan, S. R., A. D. Sule, and R. Chatterjee. 1966. Relationship between lanthionine content and permanent set and supercontraction of wool fiber. *Textile Research Journal* 36(12). (A7-AMS-12)

Bhan, M. M. and A. D. Sule. 1967. The effect of sunlight on canary-stained wools. *Journal of the Textile Institute* 58(1). (A7-AMS-12)

Prevention of Insect Infestation

Bry, R. E., and J. H. Lang. 1966. Mothproofing investigations with Bay 77488. Abstract in *Bul. Ent. Soc. Amer.* 12(3): 305. (MQ 1-26)

Bry, Roy E., L. L. McDonald, and Joe H. Lang. 1966. Mothproofing investigations with barthrin and dimethrin. *Jour. of Econ. Ent.* 59(5): 1108-1110. (MQ 1-26)

Bry, Roy E., L. L. McDonald, and Joe H. Lang. 1967. Quaternary ammonium compounds as mothproofing agents. *Jour. of Econ. Ent.* 60(1): 203-207. (MQ 1-26)

USDA, Office of Information. 1966. Protect woolens against insects. (New USDA bulletin tells how.) In *Food and Home Notes*, pp. 2-3, July 6. (MQ-1)

USDA, Office of Information, Radio and Television Service. 1967. Moths and beetles. In *TV Home Features*, May. (MQ-1)

POULTRY PRODUCTS - MARKET QUALITY
Market Quality Research Division, ARS

Problem. Technological developments continue in the poultry industry and create many new problems relating to the market quality of poultry and egg products. Introduction of highly mechanized equipment and machinery plus new techniques in processing affect the absorption and retention of moisture of ready-to-cook poultry, the contamination of poultry and egg products by spoilage microorganisms, the physical damage to poultry carcasses, and the sanitary and functional properties of egg products. To maintain quality of these products in marketing channels, more information is needed regarding the effects of the new technology as well as changes that occur during transportation and storage. In addition, objective methods of quality evaluation are needed for use in developing improved criteria and standards for inspection and grading to insure uniform, standardized and wholesome products.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving food technologists and bacteriologists engaged in basic and applied research in the quality evaluation and quality maintenance of poultry products. This research is conducted at Beltsville, Maryland, Athens, Georgia and through research agreements and contracts with Iowa State University, Ames, Iowa; the University of Delaware, Newark, Delaware; and Oklahoma State University, Stillwater, Oklahoma.

A P.L. 480 grant was made to the Centro Experiment del Frio, Madrid, Spain, for a study of changes occurring in egg whites during cold storage. Its duration is for 3 years (1964-67) and involves P.L. 480 funds with a \$26,370 equivalent in Spanish pesetas.

The Federal scientific effort devoted to research in this area totals 4.8 scientist man-years; objective measurement and evaluation of quality, 3.8, and handling, packaging and storage, 1.0.

The line project "Determination of lighting and other visual environmental requirements for proper grading and inspection of poultry" was terminated during this period. (MQ 3-52)

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 12.9 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality measurement and evaluation of quality

1. Detection of Salmonella in Poultry and Egg Products. The technique for screening *Salmonella*-negative samples of dried egg was refined, including construction of a special glass flask with three side-arm tubes. Mannitol purple agar and SIM agar, can be added directly to the tubes so that these media are in contact with the lactose pre-enrichment broth in the main part of the flask. Selenite-cystine or tetrathionate can be added to the third tube thus facilitating isolation of bacteria in the event of a positive reaction in either the MP or SIM tubes. A study was initiated to compare various pre-enrichment ("primary enrichment") media in combination with various enrichment ("secondary") media for recovery of salmonellae in egg products. (MQ 3-74)

2. Lighting Requirements for Proper Inspection of Poultry. A study of the effect of quality and intensity of light in judgment of colors encountered in poultry inspection was completed. Four types of fluorescent lamps, both alone and supplemented with two types of incandescent lamps were evaluated at 50 and 100 foot-candles intensities. Twelve observers made 25,920 judgments of paired color chips that represented colors of importance in post-mortem inspection of poultry carcasses. Significantly fewer errors (color chips actually alike judged to differ) were made at 100 than at 50 foot-candles. The type of light sources or combinations had no significant effect on the number of incorrect judgments. (MQ 3-52)

3. Detection of Pesticide Residues in Poultry and Egg Products. Work was continued to improve the thin-layer chromatographic technique for detection of chlorinated hydrocarbon pesticide residues in poultry and egg products. Cleanup of rendered chicken fat was improved by employing a column of smaller diameter and greater length which aided in retention of the fat. Changes in volume or concentration of some of the reagents and modification of thin-layer plates are being used to develop a more rapid technique. The modifications also appear to contribute to a more accurate determination of pesticide with very low RF values, e.g., methoxychlor. (MQ 3-70)

B. Quality maintenance in handling, packaging and storage

1. Quality of Chicken Fryers During Holding in Various Shipping Containers. Determinations were made of bacterial counts, changes in carcass and box weights, and degree of ice retention in wirebound crates, and corrugated fiberboard (wax impregnated) and polystyrene boxes during holding of ready-to-cook chicken fryers at various temperatures for periods up to 2 weeks. After 24 hours at 23.9° or 31.1° C., fluid drainings from wirebound crates packed with 9.1 kg of ice had higher bacterial counts than fluid from fiberboard and polystyrene boxes with 9.1 kg of ice. Breast skin bacterial counts were higher on chickens in wirebound crates than in polystyrene boxes with either 9.1 or 6.8 kg of ice over 13 days of storage at 4.4° C. Chickens in

fiberboard boxes with 9.1 kg of ice exhibited higher bacterial counts than those in polystyrene boxes with 9.1 kg of ice during 13 days of storage at 4.4° C. A greater percentage of ice was lost in wirebound crates than in fiberboard boxes, and the loss in fiberboard was greater than in polystyrene boxes, during 6 day storage at 4.4° C. Weight loss of carcasses in wirebound crates was higher than those in fiberboard or polystyrene boxes during the same period. This work was carried out in cooperation with the Transportation & Facilities Research Division, ARS. (Exploratory)

2. Frozen Poultry Shipments to Europe. Research on effect of packing and boxing techniques on quality and condition of frozen poultry shipped to European markets by refrigerated van container was conducted in cooperation with the Transportation & Facilities Research Division, ARS. Light weight boxes were adequate and no strapping of boxes was required to protect the product for van container shipments. Temperature control and reliability were satisfactory. (Exploratory)

3. Shelf Life of Chickens Packed in Carbonated Ice. Eviscerated fryer chickens packed with carbonated ice in conventional wirebound or fiberboard shipping containers did not differ significantly in bacterial condition from those packed with ordinary water ice during storage for 11 days at 1° C. (Exploratory)

4. Post Chill Washing of Fryer Chickens. In an in-plant study, spray washing of fryer chickens with a commercial type washer shortly after chilling with or without chlorine (10, 20 and 50 ppm) did not significantly reduce the total bacterial count or the numbers of psychrophiles on the skin surface. (Exploratory)

5. Microbiology of "Further Processed" Turkey Products. "Further processed" turkey products prepared from chilled eviscerated carcasses at two commercial turkey processing plants were analyzed for salmonellae, coagulase positive staphylococci and total aerobes. Salmonellae were isolated from swab samples from 14% of chilled carcasses, 27% of raw finished products (uncooked) and 24% of processing equipment. The same serotypes as those found throughout the plant on any one visit were recovered from 31% of rinse samples taken from hands and gloves of processing personnel. Salmonellae were found in samples taken on 37 of 48 visits; a greater number of recoveries being made on days when freshly killed turkeys were processed (87%) than when frozen defrosted carcasses were processed (59%). Salmonella san diego and Salmonella anatum were predominant among the 23 serotypes recovered. Staphylococcus aureus was recovered from about 60% of swab samples of the surface of raw rolls, but no recovery was made from the cooked rolls. Ingredients contained no coagulase positive staphylococci and less than 300 aerobes per gram. Throughout evisceration and further processing, an important source of staphylococci was worker's hands. These studies are being conducted at Iowa State University under contract. (MQ 2-113(c))

6. Chemical Changes in Broiler Carcasses During Refrigerated Storage. Infrared spectrophotometric evaluation of skin surface lipids of chicken broiler carcasses revealed a progressive increase in the ratio of transmittance at 6.1 microns to that at 3.4 - 3.5 microns as storage time increases. A leveling off of the ratio coincided approximately with the onset of spoilage off-odors. (Exploratory)

7. Changes Occurring in Egg White During Storage. Physical and chemical determinations were made on water thermostabilized (60° C. - 4 minutes) and untreated shell eggs stored at 0° and 15° C. for periods up to 9 months. Shell eggs held in a 4.5% CO₂ atmosphere at 0° C. were also included in the study. All eggs were maintained at 85 to 90% relative humidity. Thermostabilized eggs exhibited a greater weight loss during storage than the other groups. At 0° C. weight loss of CO₂-held eggs was greater than that of untreated eggs. Formation of thin white was lowest in thermostabilized eggs; at 0° C., percent thin white of these eggs showed the least variation throughout storage. CO₂-held eggs showed the greatest increases in percent thin white. Electrophoretically, lysozyme appeared to form two complexes during storage; one anionic - possibly conalbumin and lysozyme and one cationic - lysozyme and ovomucin. The lysozyme and ovomucoid fractions disappeared during storage at 15° C. but only a slight regression of these components was noted in eggs stored at 0° C. The free amino acid content of the white of all eggs increased with storage; alanine, valine, methionine and glutamic acid were found most often. (E25-AMS-8(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Measurement and Evaluation of Quality

Banwart, G., A. J. Mercuri and T. Ryan. 1966. Screening method for Salmonella-negative samples of dried egg (Abstract). Poultry Sci. 45(5): 1067-1068. Also presented at Poultry Science Association Meeting at Logan, Utah, August 16, 1966. (MQ 3-74)

Moats, W. A. and A. W. Kotula. 1966. Single step cleanup of chlorinated pesticide residues, using high elution rates. Jour. Assoc. Offic. Anal. Chem. 49(5): 973-975. (MQ 3-70)

Quality Maintenance in Handling, Packaging and Storage

Berman, M. D. and A. W. Kotula. 1966. Relationship between age and haemoglobin splitting activity in chicken muscle. Nature 210(5042):1271-1272.

Kotula, A. W. and N. V. Helbacka. 1966. Blood volume of live chickens and influence of slaughter technique on blood loss. Poultry Science 45(4): 684-688. (MQ 2-81)

- Mercuri, A. J., A. W. Kotula and D. H. Sanders. 1966. Low dose ionizing irradiation of tray-packed cut-up fryer chickens. Poultry Science 45(5): 1105. (Abstract)
- Taylor, M. H., N. V. Helbacka and A. W. Kotula. 1966. Evacuated packaging of fresh broiler chickens. Poultry Science 45(6):1207-1210. (MQ 2)
- Thomson, J. E., G. J. Banwart, D. H. Sanders, and A. J. Mercuri. 1967. Effect of chlorine, antibiotics, B-propiolactone, acids, and washing on Salmonella typhimurium on eviscerated fryer chickens. Poultry Science 46(1):146-151. (MQ 2-135)
- daSilva, G. A. N., A. A. Kraft and J. C. Ayres. 1967. The occurrence of Staphylococcus aureus in cooked and uncooked turkey rolls. Bact. Proc., p. 12. (MQ 2-113(c))

DAIRY PRODUCTS - MARKETING FACILITIES,
EQUIPMENT AND METHODS
Transportation and Facilities Research Division, ARS

Problem. The equipment, work methods, and facilities used by many dairy plants are obsolete and the production per man-hour employed relatively low. A major factor contributing to this obsolescence is the development during the last few years of new types of equipment which can be brought under automatic control. Because of the investment required and the uncertainties of the returns they would obtain, plant operators have been reluctant to shift to automated equipment on a piecemeal basis. They also have been reluctant to build new plants because of a lack of guidelines and criteria on automated plants. However, studies indicate that it is possible in fully automated plants to increase the productivity of labor 100 percent or more, to improve the qualities of the finished products, and to develop better management-employee relations. Engineering layouts and operating criteria therefore are needed for automated plants to provide guides to plant operators in making the shift from their present equipment and facilities. Most dairy plants lack the technological and engineering skills necessary to plan and develop suitable plant layouts and designs, or to select the types of equipment needed and the controls necessary for full automation. Automated equipment and processes for some types of dairy plants still largely are lacking or are nonexistent. Therefore, engineering research also is needed to develop equipment and processes for automating these plants in order to increase labor productivity and improve product quality.

USDA PROGRAM

The Department has a continuing long-term research program involving agricultural engineers and dairy technologists engaged in applied research to develop improved methods, equipment, operating criteria, and plant layouts for dairy plant operators.

Current research covers the development of layouts and operating criteria, based on current technology, for automated dairy product plants. It features the use of remotely controlled air operated valves, electronically controlled devices, and highly mechanized equipment to facilitate automated processing and CIP cleaning in dairy plants. The work is carried out at Hyattsville, Md., and Columbia, Mo. Work in the Hyattsville, Md., office consists of checking, organizing, and preparing for publication a series of reports prepared under contract. Work at the Columbia, Mo., field location, which is conducted in cooperation with the Missouri Agricultural Experiment Station, consists of collecting, analyzing, and preparing for publication engineering data, from studies in both laboratories and commercial plants, needed for efficient utilization of automated procedures in fluid milk plants.

The Federal effort devoted to research in this area is 1.3 scientific man-years; 1.0 man-year for intramural work and 0.3 man-year for program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Layouts and Operating Criteria for Automated Dairy Product Plants

At Hyattsville, Md., work was continued on the preparation of a series of contract reports covering the development of layouts and operating criteria for different types of automated dairy product plants. Three of the six contract reports have been published. The status of the work on the three remaining reports in this series is as follows:

1. Plants Manufacturing Cottage Cheese, Cream Cheese, and Cultured Milk and Cream. Changes recommended by Division Editor to improve clarity are underway. Results previously covered.
2. Plants Manufacturing Cheddar Cheese. Manuscript completed and ready for review at the end of the report year. Results previously covered.
3. Plants Manufacturing Sweet Cream Butter and Dried Nonfat Milk. The manuscript for a Department publication, based on the contractor's report, was about 90 percent complete at the end of the report year. Results of this research were covered in last year's report.

B. Increasing Efficiency Through Optimum Utilization of Automation in Fluid Milk Plants

At Columbia, Mo., research using the University of Missouri dairy plant as a laboratory for tests and experiments on automation problems was continued. Installation of the automated equipment in the University dairy plant was completed. The following items were operational at the end of the report year:

1. The valving assemblies for the raw and pasteurized milk tanks.
2. The automated CIP (Cleaning-in-place) system for the milk storage tanks and processing line.
3. The automated sanitizing of the processing line.

Labor requirements on the partially automated plant were determined during the year as different components of the automated equipment were installed. Control equipment was designed and installed, which permits the milk processing line to be completely CIP cleaned. Use of the system reduces the labor required for cleaning of the processing lines since no equipment must be disassembled and washed by hand. Approval of the system for

test purposes in the University dairy plant has been granted by the Division of Health of Missouri and the control circuitry has the tentative approval of the U.S. Public Health Service.

Experiments to determine the parameters for cold water cleaning and meter type measurement of detergents into a CIP system were underway at the end of the report year.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Layouts and Operating Criteria for Automated Dairy Product Plants

Tracy, P. H. 1966. Layouts and Operating Criteria for Automation of Dairy Plants Manufacturing Ice Cream and Ice Cream Novelties. Marketing Research Report 750. December 1966.

Increasing Efficiency Through Optimum Utilization of Automation in Fluid Milk Plants

Anderson, M. E. and Morris, H. A. 1966. This Problem of Waste Disposal - An Analysis of Systems Used by Selected Dairy Plants. (Series of three articles) Manufactured Milk Products Journal. August-October, 1966.

LIVESTOCK, MEAT, AND WOOL - MARKETING FACILITIES
EQUIPMENT AND METHODS
Transportation and Facilities Research Division, ARS

Problem. Many of the livestock, meat, and wool marketing, slaughter, and warehouse facilities occupied today are obsolete and the work methods that can be used in such facilities are antiquated. As a consequence, labor costs are excessive and they are increasing. Many firms still are occupying facilities designed primarily for handling rail receipts and rail shipments even though the majority of these products today are moved by motortruck. This situation also adds to handling costs. Numerous firms are occupying "makeshift" facilities which were designed for other uses or for work methods and operations of a bygone era when labor costs were low. Changes in transportation systems, population growths and shifts, and advancements in technology also have brought about changes in the types of facilities--such as livestock auction markets, commercial feedlots, hotel supply houses, and specialty meat processing plants. Most private firms handling livestock, meat, and wool lack the technological and engineering skills necessary to plan and develop suitable facility layouts and designs and to select the types of equipment needed. Therefore, engineering and related research is needed to provide guidelines for industry to increase efficiency; including the designing of improved plant layouts, which will provide proper arrangement of work areas to minimize travel distances and excessive handling and the development of work methods that will permit use of mechanized and automated equipment rather than the relatively high-cost manual methods now used in many plants.

USDA PROGRAM

The Department has a continuing long-term marketing research program involving agricultural and industrial engineers, agricultural economists, and meat scientists engaged in both basic and applied research to develop new and improved methods, equipment, processes, and facilities for livestock markets, meatpackers and wholesalers, and wool warehousemen. Livestock market research is carried on at Columbia, Mo., in cooperation with the Missouri Agricultural Experiment Station. Part of this work also is in cooperation with the Central Missouri Livestock Auction, Mexico, Mo. One livestock market research project is conducted under a research cooperative agreement with the Computer Research Center, University of Missouri, Columbia, Mo. Research on livestock slaughtering and on meatpacking and wholesaling is headquartered at Stillwater, Okla., and is cooperative with the Oklahoma Agricultural Experiment Station. One segment of the meat research is conducted under a research cooperative agreement with the Nebraska Agricultural Experiment Station, Lincoln, Neb. Wool warehouse research will be conducted at the Columbia, Mo., field location.

The Federal effort devoted to research in this area totals 5.1 scientific man-years; 2.0 man-years (1.2 man-years intramural and 0.8 man-year extramural) on livestock; 2.4 man-years (2.0 man-years intramural and 0.4 man-year extramural) on meat; and 0.7 man-year on program leadership. No research is currently being done on wool warehouses.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Automation of Sales Operations on Livestock Markets

Electrically operated gates, developed under a research cooperative agreement with the Missouri Agricultural Experiment Station, continue to operate very satisfactorily. Prototype gates have been in continuous use at the entrance and exit of the sales ring on the Central Missouri Livestock Auction, Mexico, Mo., for about 18 months.

Plans for the electric gate have been provided to a terminal stockyards company which installed gates in the sales ring of its new feeder cattle auction facility. These gates have now been operating successfully about 6 months. Several other market operators have indicated they are considering installing electrically operated gates on their sales ring.

A descriptive report entitled "Electrically Operated Gates for Livestock Markets" was completed and published in April 1967. A second and final report providing construction details, drawings, and additional information on the prototype gates is in draft form and will be published by the Missouri Station during the Fiscal Year 1968.

B. Automating the Processing of Sales Data on Livestock Markets

A computer system for processing sales and accounting data on livestock auction markets has been developed under a research cooperative agreement with the Computer Research Center, University of Missouri, Columbia, Mo. The types of information needed for efficient handling of sales data were determined from analyses of current handling procedures and office records. Core space (information storage) requirements were based on the volume of information to be processed on a peak volume day.

Components of the system were selected from commercially available equipment capable of processing the types of information needed, providing adequate core space, and having sufficient operating speed to keep abreast of the fastest selling operation. Due consideration was also given to simplicity and economy in selecting components.

The system uses an IBM 1130 computer, an IBM 514 reproducing punch for use with mark sense cards, sorting and print-out machines. The computer has been programmed and laboratory tested and the complete experimental system installed on the Central Missouri Auction Market, Mexico, Mo. In market testing, the auction clerk uses a lead pencil to mark the coded information for a sales transaction on a preprinted mark sense card, the card is transmitted to the market office through a pneumatic tube, the IBM 514 automatically translates the coded pencil marks into punches on the card, and the card is fed into the computer. The computer calculates total price of the transaction; deducts commission charges, insurance, feed, transportation, and other applicable fees; and makes appropriate entries on the buyer's invoice. The mark sense card provides a permanent record of the transaction.

The computer system minimizes the possibility of errors in computations and preparation of records and accounts, speeds up payment for animals following their sale, provides accurate permanent records of all business transacted and could easily be programmed to handle routine accounting tasks such as payrolls. By leasing computer time to or from other firms in their respective localities, the system can be used economically on most of the 1,725 auction markets in the U.S.

The tests under actual market conditions will be completed and a manuscript covering the result will be prepared during the Fiscal Year 1968.

C. Layouts and Operating Criteria for Livestock Auction Markets

At Columbia, Mo., research to update and broaden work previously done by the Branch on improving layouts, work methods, equipment and facilities to increase operating efficiency was initiated in November 1966. Field data were collected on market layouts, flow patterns, handling methods, weighing and selling practices, volumes handled, and labor requirements on selected livestock auction markets in the Midwest, Southeast, and Appalachian areas of the United States. Work has not progressed to the point where research results can be reported.

D. Layouts and Work Methods for Hog Slaughtering Plants

At Stillwater, Okla., in cooperation with the Oklahoma Agricultural Experiment Station, a manuscript entitled "Hog Slaughtering and Dressing Systems" was completed and published in September 1966. Results of this research were covered in previous reports.

E. Layouts and Work Methods for Hotel and Restaurant Meat Supply Houses

At Stillwater, Okla., a manuscript entitled "Hotel and Restaurant Meat Purveyors--Custom Service Houses--Improved Methods and Facilities" was completed and published in July 1966.

At Hyattsville, Md., an article entitled "USDA Tests Show Promising Ways to Cut Custom Meat Order Costs" was published in the August 1966 issue of Agricultural Marketing.

At Stillwater, Okla., a manuscript entitled "Hotel and Restaurant Meat Purveyors--Frozen Portion Control Houses--Improved Methods and Facilities" was returned to the author in April 1967 so that data on recently introduced meat fabrication equipment could be included in the manuscript.

The significant results of the research covered by these manuscripts were covered in earlier reports.

F. Layouts and Work Methods for Small Inedible Rendering Plants

At Stillwater, Okla., field studies were conducted in several rendering plants ranging in size from a one-cooker batch system to a six-cooker operation, plus one continuous rendering system. Based on analyses of these data, discussions with plant owners and managers, and requests for assistance from public agencies and industry groups, it appears that limiting this research to increasing operating efficiency in small inedible rendering plants would not provide the rendering industry adequate guidelines and assistance for management decisions. As the primary interest among renderers today concerns Salmonella control and in response to a request from ARS' Animal Health Division for cooperation on the Salmonella problem, this project has been reoriented to include work on developing suggested layouts, equipment modifications, and operating procedures which will affect Salmonella control and thus be more beneficial to the industry. At the end of the fiscal year this research was being reorganized to include both operating efficiency and Salmonella control.

G. Handling and Processing "Hot" Pork Carcasses

During the report year, a research cooperative agreement was negotiated with the Nebraska Agricultural Experiment Station, Lincoln, Neb., to design and test a pilot line, including a continuous flow chill cabinet, for handling and processing "hot" pork products. Plans were developed to move this research from a laboratory feasibility study to the development of prototype equipment and the design of a pilot line operation for use in a commercial packing plant. Based on data developed in the feasibility study, working drawings and specifications have been prepared for the construction of a prototype continuous flow chill cabinet. An agreement has been drafted which provides for tests under actual operating conditions in a commercial packing plant; and at the end of the report year negotiations were underway with a prospective cooperating packer. During fiscal year 1968 it is anticipated that prototype equipment will be constructed and laboratory tested in preparation for actual operating tests in a commercial plant.

H. Layouts and Work Methods for Beef and Veal Boning Lines

At Stillwater, Okla., field work was continued on research to develop more efficient work methods, equipment, and layouts for beef and veal boning lines. Data from case studies completed to date have been compiled and tentative results show that a well planned conveyORIZED line boning about 100 carcasses daily requires three fewer workers and about 20 percent less floor space than a conventional manual line. Comparable savings should be realized for lines handling larger volumes.

A manuscript tentatively entitled "Evaluation of Bone Handling Procedures for Beef Boning Lines" was in rough draft form at the end of the report year. The report provides data on types of equipment and procedures for handling bones at various volumes and transport distances. The conventional boning table and general purpose truck are the most efficient at volumes up to 100 head daily and a transport distance up to 65 feet. For volumes of 100 to 185 head and distances up to about 50 feet, a belt conveyor and truck combination is the most economical. A conveyORIZED system is recommended for larger volumes and greater distances.

Some preliminary work has been done on reworking bones removed from carcasses to recover the meat left by the boner. The findings to date are that about 20 pounds of usable meat per 100 pounds of carcass bones can be salvaged. These data were developed from bones supplied by only one boning establishment. Additional work will be done on carcass bones obtained from other boning lines. Also, investigations will be made to determine if the meat reclaimed justifies the labor, equipment, and space needed for the operation.

I. Methods, Equipment and Facilities for Specialty Meat Plants

At Stillwater, Okla., field studies to collect data for the development of suggested layouts for small, medium and large sausage processing plants were completed. The data obtained served as a basis for developing labor, equipment and maintenance requirements and costs and layouts representing a small plant at 37,500 pounds product output annually, a medium size plant at 75,000 pounds output and a large plant at 187,500 pounds output. From this data, labor and equipment requirements were synthesized for volumes representing a 33 1/3 percent increase and decrease in production from each of the established plant outputs. Thus, data were provided for plants producing at 9 different levels of output.

Agricultural Economists of Oklahoma State University used these data in projecting total plant costs necessary to construct and operate sausage plants representative of these sizes in the Oklahoma area. Portions of these data have been incorporated in an Oklahoma State University report entitled "Economics of Size in Non-Slaughtering Meat Processing Plants."

At the end of the report year, these data were being evaluated to determine what additional information would be needed to prepare a Department publication on increasing efficiency in sausage processing plants.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Automation of Sales Operations on Livestock Markets

Mayes, Herman F., Obermeyer, James H., and McKibben, J. S. 1967.
Electrically Operated Gates for Livestock Markets. ARS 52-21, 12 pp.

Layouts and Operating Criteria for Livestock Auction Markets

Webb, Tarvin F. 1967. Improving Operating Efficiency on Livestock Auction Markets. Paper presented at the Annual Meeting of the Virginia Association of Livestock Markets. Charlottesville, Va. January 14, 1967.

Layouts and Work Methods for Hog Slaughtering Plants

Hammons, Donald R. 1966. Hog Slaughtering and Dressing Systems. Marketing Research Report 755. September 1966.

Layouts and Work Methods for Hotel and Restaurant Meat Supply Houses

Brasington, Clayton F. 1966. Hotel and Restaurant Meat Purveyors--Improved Methods and Facilities for Custom Service Houses. Marketing Research Report 747. July 1966.

Brasington, Clayton F. 1966. USDA Tests Show Promising Ways to Cut Custom Meat Order Costs. Agricultural Marketing, August 1966.

General

Hammons, Donald R. 1967. The Change to On-The-Rail Dressing Systems. Paper presented at the Annual Meeting of the Texas and Southwestern Meat Packers Sausage Institute, Texas A. and M. University, College Station, Texas, April 29, 1967.

**POULTRY AND EGGS - MARKETING FACILITIES,
EQUIPMENT AND METHODS
Transportation and Facilities Research Division, ARS**

Problem. Although the production of meat classes of poultry has tended to level off, the rapidly developing demand for further processed poultry meat items, in addition to a strong demand for the traditional whole bird, has resulted in significant changes in methods of product preparation which have increased the demand for equipment and facilities that encourage sanitary and efficient operations. Similarly the production of fine quality eggs from large commercial flocks, that are now the major source of table quality eggs throughout the country, calls for drastic changes in the facilities, equipment and methods for preparing eggs and egg products for market. These changes have had an impact on the poultry processing and egg grading and packing plant operations throughout the country. In adjusting to these changes industry has tried in many cases to work out the problems involved on an individual plant basis. In the main, the changes effected, have furnished only temporary relief in the area of plant expansion needs and are of little help in developing guidelines for new plants or in solving general plant production problems and problems involving new processes. The research that the Department has undertaken in this area has been successful in developing some of the basic guidelines that industry needs and that are now being effectively used by many plant operators. However, in order to continue to improve operating efficiency in existing facilities, and to be in position to provide effective assistance in planning new or expanded facilities needed in connection with many of the recent food processing and marketing trends; develop plant layouts, devices, and equipment, and efficient work methods for the handling, processing, grading, and packing of poultry, eggs and egg products in this changing environment; this research effort needs to be continued and expanded.

USDA PROGRAM

The Department has a continuing long-term program involving engineers and marketing research analysts engaged in both basic and applied research to develop more efficient work methods, techniques, operating procedures, devices, and equipment and to design improved facilities for the handling and preparation for market of poultry, eggs, and egg products. Research on chicken-class poultry processing operations is carried on in commercial poultry processing plants in the Southeast by Department personnel at Athens, Ga., in cooperation with the College of Agriculture Experiment Stations, University of Georgia. Research on turkey-class poultry processing, egg products processing, and the cleaning, grading, and packing of shell eggs is carried on in West Coast turkey processing facilities and in egg grading and packing plants, in cooperation with the California Agricultural Experiment Station at Davis. Contract research to design, construct and test a mechanized turkey deboning line to increase

productivity and maximize the yield of prime deboned meat cuts, is being carried out by the Gordon Johnson Company, Kansas City, Mo.

The Federal effort devoted to research and development work in this area during the Fiscal Year 1967 totaled 4.6 scientific man-years of which 2.6 man-years (including 0.5 man-year of contract work and 0.1 man-year under a cooperative agreement with the University of Georgia) is devoted to poultry; 1.0 man-year (including 0.4 man-year under a cooperative agreement with the University of California) to shell eggs and egg products; and 1.0 man-year to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Methods, Equipment, and Facilities for Grading and Packing Eggs

This research completed in Hyattsville, Md., last year was reported in MRR-744 "Evaluation of Mechanized Egg-Grading and Packing Equipment." It evaluates and compares the principal mechanized egg grading and packing lines and provides guidelines for egg grading plant operators in determining the degree of mechanization that should be most efficient in their respective operations and in selecting the combinations of mechanized egg grading and packing equipment that will yield the greatest output per worker and equipment dollar at specified production and product quality levels.

B. Improved Methods, Techniques and Equipment for Cleaning Eggs

This research, completed at Davis, Calif., last year was reported in MRR-757 "Improved Methods, Techniques, and Equipment for Cleaning Eggs." It provides machine design specifications and time, temperature, and sanitation requirements for operating and maintaining egg cleaning equipment that maximizes the yield of clean eggs while minimizing breakage and hazards from spoilage organisms.

C. Improved Layouts and Engineering Designs for Egg Grading and Packing Plants

This long term research carried on at Davis, Calif., is directed toward the development of improved building design and layouts for small egg grading and packing plants involving preparation of engineering design drawings, the development of building specifications, and facility and equipment layouts. The recent trend in the poultry industry indicates a need for small efficient egg grading and packing plants where the production of a few large commercial flocks are handled on one of the farms. This trend has given rise to a need for information on plant facilities including equipment arrangements, storage space requirements, egg cooling facilities, and structural design guidelines. The average operator of a small plant, generally has started operations in a small makeshift facility and then as flock size and production increased, the plant has been enlarged, creating

inefficient operations and hazards to product quality. This situation has created a need for layouts which are designed to meet expansion needs.

During the earlier phases of this research a number of commercial plants within the desired size range were studied to evaluate the problem areas and to provide a basis for designing improvements. Building specifications, layouts, and functional area space requirements were determined to furnish guidelines for setting up design criteria.

During the report year a layout and design manual was prepared in draft form. Materials handling, materials storage, processing areas and product storage were considered individually and jointly in terms of overall arrangement, inter-relationship, expansion potential, and structural design requirements. Procedures for calculating initial and changing space requirements, and techniques for planning functional work and storage areas were developed for a wide range of operating conditions. Structural design specifications and engineering drawings have been prepared for the typical plant in this volume range.

D. Development of Equipment and Methods For Pasteurizing Liquid Whole Eggs In Small Volume Egg Breaking Rooms

This research, which is carried out under a research cooperative agreement by the University of California's Department of Food Science and Technology, is part of a long range program at Davis, Calif. It is designed to develop pasteurizing equipment that will meet the needs of small egg grading and packing plants that have found it advantageous to break out and freeze undergrade eggs, instead of marketing them in the shell at a considerable loss. With recent requirements calling for the pasteurization of liquid eggs by both State and Federal authorities, an urgent need has arisen for equipment that can handle the production of these small volume operators as effectively as pasteurizing equipment presently employed in large volume plants.

Under this project studies have been made of egg pasteurization by the batch method (because of its adaptability to handling small quantities of liquid) to establish a balance between time and temperature parameters that will provide the necessary microbial kill without damage to the functional properties of the egg liquid and to determine the feasibility of designing equipment for operation under varying conditions of product volume and temperature.

During the report year three small commercial vats were used to test the time and temperature requirements for both heating and cooling commercial quantities of liquid egg under various operating conditions explored earlier with small scale laboratory vessels. Tests were conducted under static conditions to determine their effect on the functional properties of the egg and lethality on Salmonella. The results showed that, although no significant changes were noted in the functional properties of the liquid

whole egg, space heating (between liquid surface and cover of the vessel) was necessary to eliminate recontamination from the foam caused in vat agitation. When space heating was used and the liquid egg was held at 135° F. for 9 minutes a 10⁶ Salmonella kill was effected. The bacteria levels of Salmonellae in unpasteurized liquid whole egg from twenty-five (25) California egg breaking rooms were determined. Theoretical calculations of the thermal death time and temperature for these bacteria were made and then verified by the results of studies of the thermal death time and temperatures recorded for actual operations. From these data, specifications for a prototype batch pasteurization unit for laboratory and commercial testing have been developed.

Three reports covering the results have been completed; one was presented at the annual meeting of the Poultry Science Association and two are being submitted for publication in the technical journal "Poultry Science."

E. Improved Methods and Equipment For Cutting-Up and Packing Chickens

This research conducted at Athens, Ga., involves a study of methods, equipment and facilities for dismembering, cutting up and packing broiler class chickens.

Time and motion studies of cut-up methods used in small volume operations (in plants where the cut-up pack mainly represents the trimmed bird fraction of a ready-to-cook whole bird ice-packed operations) were completed and development of an efficient small cut-up line layout was started.

The study of cut-up operations was expanded to include large volume operations in Georgia and North Carolina.

Developmental work on mechanizing the cut-up operation was initiated. A machine for splitting the breast while removing the backbone was designed, constructed and tested both in the laboratory and in commercial plants. Only minor design changes appear to be needed before full-scale field trials are undertaken. It is estimated that the machine can reduce the labor costs of the breast cutting operation by 50 percent while reducing worker injury hazards and improving cutting accuracy and consistency. Disclosures required in preparing an application for a public patent are being undertaken.

F. Improved Layouts and Designs for Poultry Processing Plants

No progress to report on this research conducted at Athens, Ga.

G. Improved Methods, Equipment and Facilities for Improving Chicken Processing Plant Efficiency Through Balanced Inspection and Evisceration Operations

This research, which was carried out under a contract with the American

Scientific Corporation, Alexandria, Va., in selected plants on the Delmarva Peninsula, was completed last year. During this report year a report on the results of the study, "Poultry Eviscerating and Inspection Efficiency" was prepared by Department personnel and has been submitted for publication. It will provide plant operators and the Department's Inspection Service with guidelines for the most efficient inspector-work crew mix at specified production levels and processing equipment combinations.

H. Improved Methods and Equipment for Handling Live Chickens by Commercial Processing Plants

This research, headquartered at Athens, Ga., involves studies of live chicken handling operations to determine the causes of the relatively high rate of bruising of live chickens prior to slaughter and to develop improvements that will reduce this costly damage to product quality with minimum additional cost.

During the report year evaluation of live chicken handling operations to determine labor requirements and locate areas or operations where downgrade bruising occurs were continued in typical commercial facilities in Georgia, North Carolina, and Virginia. The research included: (1) A study of the equipment and facilities employed in approximately 40 live handling operations and detailed analysis of the work methods used; (2) motion picture records of three experimental mechanical loading systems to document advances made in mechanization of the operation and as a guide for improvements that might be developed; (3) studies to determine the source of downgrading damage to chickens during specific live handling, transport and grow out operations; and (4) the second of a more extensive series of tests (100 birds from 30 different Georgia flocks) to confirm the amount of bruise damage prevailing in the commercial flocks prior to the arrival of live handling crews. In an attempt to make the data from the Georgia tests more meaningful and to correlate the housing conditions to a specific situation, similar data were collected from 50 Virginia grower houses of various sizes and layouts and using different types of equipment.

Results show that chickens are not likely to be bruised enroute from the farm to the processing plant but that more than 50 percent of the bruised live birds had been bruised prior to the arrival of the catching crews.

Studies of the use of limited external stimuli (light and sound) indicate that blue-white lighting during the grow-out period (white lights turned off and blue lights turned on when caretaker enters flock quarters) has a quieting effect on chickens that results in fewer bruises at the time of catching. Arrangements have been made to confirm these results by large scale tests.

Experimental mechanized coop loading equipment to reduce bruise damage to chickens during live handling and to reduce labor requirements and drudgery of catching and loading chickens was designed, constructed and tested in the

laboratory. The equipment consists of a conveyor system to transport chickens onto the truck and dispense them into the coops with a minimum of handling by the crews. The test results are encouraging but further design modifications are necessary before commercial scale tests can be undertaken.

I. Improved Methods, Equipment and Facilities for Chilling, Weighing, and Packing Turkeys

The field studies for this research, conducted at Davis, Calif., covering the development of improved methods and equipment for weighing and packing turkeys were completed last year. A report "Improved Equipment for Weighing and Packing Turkeys" setting forth the results has been prepared, cleared and submitted for publication. It presents the design detail for a semi-mechanized turkey packing line that reduces labor requirements required for preparing the turkey for weighing, placing it in a plastic bag, marking the exact weight on the bags and sealing it. These studies show a possible labor saving of 15 percent as compared with conventional equipment and methods.

J. Improved Methods, Equipment and Facilities for Preparing Turkey Specialty Items

This research, carried out on an in-house basis at Davis, Calif., and under contract with the Gordon Johnson Co., Kansas City, Mo., is directed toward an engineering analysis of the current methods, equipment and facilities for dismembering and deboning turkeys and the development of improved equipment, facilities and work methods for decreasing labor inputs and yield of prime meat cuts while keeping hazards to product quality at a minimum. Evaluation of current methods, equipment and facilities is being carried out by Department personnel; and the designing, construction and testing of a mechanized deboning line is being carried out under contract.

During the report year, observations made of typical turkey deboning operations and evaluation of selected phases provided Department researchers with an understanding of the critical problems in mechanizing the process as it is currently carried on in commercial plants.

Department researchers worked with the contractor in selecting a processing plant in which a typical deboning operation could be evaluated (for comparison with performance of the experimental line later) and where management would also cooperate by permitting installation and testing of an experimental line.

The contractor's initial report containing a description of and design and structural specifications for a proposed mechanized line was unacceptable because it lacked engineering data to support a number of critical design features. Development of the necessary supporting data was started.

The design of a powered cutting tool for the efficient removal of meat from the turkey carcass was made by Department researchers. Components for its construction are presently being procured. After construction and testing it is planned to use the tool on a conventional line and on the experimental line.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Methods, Equipment, and Facilities for Grading and Packing Eggs

Forbus, Jr., W. R., and Hamann, J. A. Evaluation of Mechanized Egg-Grading and Packing Equipment. Marketing Research Report No. 744, July 1966.

Hamann, J. A. 1966. Egg Plant Equipment and Layout. A technical paper presented at the Neppco Egg Quality School, Blacksburg, Va., July 1966.

Improved Methods, Techniques and Equipment for Cleaning Eggs

Hamann, J. A. 1966. An Improved Egg Cleaner. A technical paper presented at the 13th World's Poultry Congress, Kiev, U.S.S.R., August 1966.

Walters, R. E.; Robbins, R. O., Brant, A. W., and Hamann, J. A. 1966. Improved Methods, Techniques, and Equipment for Cleaning Eggs. Marketing Research Report No. 757, October 1966.

Improved Layouts and Engineering Designs for Egg Grading and Packing Plants

Walters, R. E., and Rodda, E. D. 1967. Egg Processing Plant Design and Layouts. A technical paper presented at the 60th Annual meeting of the American Society of Agricultural Engineers, Saskatoon, Saskatchewan, Canada, June 1967.

Development of Equipment and Methods for Pasteurizing Liquid Whole Eggs in Small-Volume Egg Breaking Rooms

Patterson, G. W. 1966. Further Developments in Batch Pasteurization of Liquid Whole Egg. A technical paper presented at the 55th Annual meet of the Poultry Science Association, Logan, Utah, August 1966.

Improved Methods and Equipment for Cutting-Up and Packing Chickens

Hamann, J. A. 1966. Poultry Meat Specialities in the United States. A technical paper presented at the University of Stuttgart, Stuttgart, Germany, August 1966.

Improved Methods and Equipment for Handling Live Chickens by Commercial Processing Plants

Childs, R. E., White, H. D. 1966. Influence of Grower House Facilities on Handling Live Chickens. A technical paper presented at the winter meeting of the American Society of Agricultural Engineers, Chicago, Ill., December 1966.

Childs, R. E. 1967. An Analysis of Live Chicken Handling Operations. A technical paper presented at the annual meeting of the Southeastern Poultry and Egg Association Convention, Atlanta, Ga. January 1967.

Childs, R. E. 1967. Live Handling of Broilers to Decrease Losses. A technical paper presented at the Eighth Annual Poultry Health and Management School, Nashville, Tenn., May 1967.

Childs, R. E. 1967. The Latest Methods and Problems of Handling Live Broilers. A technical paper presented at the annual meeting of the Alabama Poultry Industry Association, Pell City, Alabama. June 1967.

Improved Methods, Equipment and Facilities for Preparing Turkey Specialty Items

Hamann, J. A. 1967. Problems and Progress in the Development of a Mechanized Deboning Line. A technical paper presented at the Poultry Further Processing Conference, Columbus, Ohio, June 1967.

CONSUMER PACKAGES, SHIPPING CONTAINERS,
TRANSPORT EQUIPMENT AND TECHNIQUES
Transportation and Facilities Research Division, ARS

Problem. It costs about eight billion dollars a year to package food products, but without shipping containers and various other types of packages it would be impossible to move farm products efficiently from the widely dispersed areas of production through our complex marketing system to millions of consumers. New or improved packages and containers must be developed and evaluated to do this job more effectively. Continuing changes characterized the American marketing system. In protecting, distributing and selling perishable agricultural commodities, packages, and containers must respond to a number of marketing system changes such as changes in (1) consumer preferences, (2) merchandising practices, (3) transportation equipment and techniques, (4) handling methods and equipment, (5) market services, (6) market organization, and (7) market outlets.

The cost of transporting farm products to market in 1966 was about five billion dollars. Cost of transporting supplies used in farm production was more than one billion dollars. Further, costs of other marketing and production functions such as loading and unloading vehicles, packaging, storage and processing also are affected by the efficiency of transport. These costs are important to the American farmer because they influence the return he receives from the sale of his products. They also are important to the American consumer because they influence the price he pays for his food. Therefore, the prosperity and efficiency of our entire agricultural industry and the economic well-being of the American consumer are closely tied to the efficiency of our transport system.

USDA PROGRAM

A. Consumer Packages and Shipping Containers

This is a continuing program of applied research conducted by marketing specialists, industrial engineers, and agricultural economists to (1) develop new or improved consumer packages and shipping containers for domestic and export marketing of agricultural products, (2) evaluate them from the standpoint of cost of materials and direct labor to pack and their ability to reduce product damage and increase product salability, (3) determine at which point in the marketing system packaging can be done most effectively, (4) improve the efficiency of packaging methods to cut costs, and (5) investigate the needs for and benefits of container standardization and simplification. Current packaging and container research is on deciduous fruits, citrus fruits, vegetables, cut flowers, poultry and dairy products, of which 0.7 SMY's are devoted to dairy and poultry products.

B. Transport Equipment and Techniques

The program pertaining to transportation involves economic-engineering research and is a long-range program. It seeks to develop improved transport facilities, equipment, and techniques and more efficient ways of using them in transporting agricultural products and supplies. It is interdisciplinary in nature, drawing upon the training and experience of economists, mechanical and industrial engineers, marketing specialists, and various other scientists. All the work is done with the cooperation of transport firms, transport and refrigeration equipment manufacturers and lessors, trade associations, State universities, and experiment stations. Field studies are carried out through the United States and on overseas shipments. Only one field station, Orlando, Florida, presently is maintained to support this research program. Part of the work is accomplished through research contracts and cooperative agreements. At the present time work is underway in each of the following fields: (1) transport equipment, (2) refrigeration equipment and techniques, (3) better utilization of transport equipment and techniques, (4) loading methods, including unitized and palletized loading, and (5) overseas transport. The program involves 12.0 scientist man-years apportioned as follows: Fruits and vegetables, 3.8; animal and animal products, 1.0; floral products, 0.8; grain and forage, 0.8; and overseas transport of fruits and vegetables, 2.8; animal and animal products, 1.1; and poultry and poultry products, 1.7.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Packages and Shipping Containers for Animal Products

1. Poultry. Ten pounds less ice is used when poultry is ice-packed in polystyrene foam boxes instead of in wirebound wood crates. Polystyrene boxes weigh four pounds less than the wirebound crates. The polystyrene box costs more than the wirebound box but savings in packing labor and package ice offset this higher cost. Significant savings in transport cost can be obtained because a packed polystyrene box weighs about 14 lbs. less than a wirebound box packed with the same amount of poultry. In a 40,000-pound truckload there would be 31,850 pounds of poultry if polystyrene boxes with 15 lbs. of package ice were used as compared to only 27,300 lbs. of poultry when wirebound boxes with 25 lbs. of ice are used. It is estimated that in the U. S. 5,179 million pounds of poultry per year are shipped in wirebound boxes with about 25 lbs. of package ice and that the average distance that this poultry is shipped from processing plant to market is 500 miles. With a truck operating cost of 36¢ per mile, the cost of a 500-mile truck shipment would be \$180 and the saving in transport cost would amount to 9.4¢ per 100 lbs. of poultry shipped -- a potential saving of 4.9 million dollars if all 5,170 million pounds of poultry shipped in wirebound crates were shipped in polystyrene boxes. Laboratory tests showed less carcass weight loss and lower microbial counts for the poultry packaged in polystyrene foam boxes than in wirebound crates.

2. Milk. A manuscript on costs for packaging and handling fluid milk in plastic packages is being prepared.

B. Packages and Shipping Containers for Overseas Markets

Poultry. The cost of shipping frozen poultry in van containers to Europe can be reduced by using cheaper lighter weight shipping containers and by elimination of metal strapping. Two van containers loaded with frozen turkeys were shipped from Virginia to Germany. The lower cost 200- and 250-pound test board fiberboard boxes performed adequately and they cost 3.5 and 2.0 cents less respectively than the commonly used 275-pound box. The nonstrapped box arrived in Europe in as good condition as the box strapped with one or two metal straps. Elimination of two straps saves 0.4 cents per box. Receivers want at least one metal strap to reduce pilferage while the boxes are being distributed from the receiving points to retail stores.

C. Transport Techniques

Overseas Transport. Research with shipments of frozen poultry to overseas markets to develop better and lower cost methods of transport and handling the products was accelerated during the year. Eight test shipments of poultry, four by van container and four by the conventional break-bulk method were made from points in Virginia, Georgia, and Iowa to markets in Germany, Italy, and Greece. Three of the shipments were paired for the purpose of comparing transport costs by van container with those by the usual break-bulk method. Data on transport and handling costs were gathered from shippers' packing plants to consignees' warehouse overseas. For some shipments total transport and handling charges were less for the van container shipments than for the break-bulk shipments. In other instances, transport charges were lower for the break-bulk shipments than for the van container shipments. The lowest cost transport method studied was a break-bulk shipment of 1,500,000 pounds of whole broilers from Georgia to Greece by a chartered refrigerated ship through the port of Charleston, South Carolina. Losses from container damage and pilferage were much lower for the containerized than for the break-bulk shipments. Product temperatures during transit were as much as 30° lower in the containerized shipments than in some break-bulk shipments. The research is being continued to develop labor and capital inputs and for more accurate measuring of transport and handling costs. An interim report on the results of this work was begun during the year.

A pallet container for shipping breeding swine overseas in jet cargo planes which allows the animals to be handled with the same efficiency as other cargo also was developed. One test shipment was made using three containers to transport both pigs and hogs to Italy. The time required to handle and transport the animals was two days as compared to two to three weeks by sea. The container can be disassembled, cleaned,

and reused or disposed of, whichever is most advantageous. Suggested design features for an aluminum livestock pallet container were given to the Reynolds Aluminum Co. who built and tested a prototype in the same test shipment with the USDA container. The aluminum container also can be reused.

The feasibility of using turkey crates as containers for shipping feeder pigs by air also was explored. Preliminary tests were made in Beltsville and a test shipment was made transporting pigs in turkey crates to Nigeria. The crates are low in cost and can be stacked on pallets for large shipments or used in small shipments carried in the cargo compartments of the airplanes.

An air cargo pallet rack made of aluminum and steel pipe for hanging beef was designed, constructed, and tested in a laboratory. The rack was covered with a disposable insulated paper blanket and loaded with ten hindquarters of beef with dry ice for refrigeration. A 24-hour stationary test to simulate handling and transit times for overseas flights was made. The test showed that disposable insulating materials can maintain desired product temperatures. Also tested were two types of insulated boxes for less-than-pallet load shipments of beef. One box was fiberboard insulated with a paper blanket and the other was made of plastic foam. The tests showed that both types of boxes give about the same protection to the product and that they should protect fresh meat products in transit overseas, if certain precautions are followed.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Transport Techniques

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ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem. The marketing system is in a constant state of change. The marketing of farm products continues to become more complex and dynamic because of advances in technology, changes in composition and location of the population, and additional demands for meeting food and fiber needs in much of the world. Not only are structural changes taking place within the marketing segment of the economy but large segments of the processing industry are relocating to meet shifts occurring in labor resources, transportation rates and services, and consumer markets.

The marketing system is imperfect. An ideal marketing system would provide the consumer with a product which has quality and product attributes measured by objective methods, accurately described by understandable terminology, and priced to reflect its true value as determined under trading arrangements where competitive forces are free to operate with adequate market information available to all sellers and buyers. The producer would have complete knowledge about the kind of a product consumers want. Also, he would receive a price that reflects the true value of his product. Handlers and processors would be able to communicate with each other and with producers and consumers in understandable terminology describing product attributes and prices that reflect value differences of well-defined gradations of quality. Our marketing system is lacking in a number of these attributes ranging from almost total deficiency in some to almost ideal in others.

Many decisions made throughout the marketing system are based on limited information. In the production of farm products most decisions are made by the producer but in marketing a great number of decisions pertaining to buying and selling, transporting, handling, storing, processing, packaging, and distribution are made by different persons. At each of these decision-making points there is opportunity to influence the margin between the farm price and the consumer price.

Research in marketing must be conducted in the marketplace. Problems cannot be transferred to a laboratory, experimental plot, or other simulated situation. Cooperation must be obtained from individuals or firms to conduct research activities with privately owned merchandise and facilities where items are bought and sold in a situation where the opportunity for profit or risk of loss exists. Only large firms can afford this type of research, consequently, public research has been requested for the many smaller firms. Furthermore, there is the need for comparison and analysis where even large firms do not have access to the plants and records of competitors.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-term program of economic research designed to provide timely and accurate market intelligence to producers, processors and distributors. The program of work involves both basic and applied aspects of marketing economics research. The program covers commodity and functional problems that are regional or national in scope. In addition to the long-term, on-going research work of the division frequently short-term, service-type assignments are carried out for the Secretary of Agriculture or other agencies within the Department having specific problems.

The mission of research in marketing economics is to provide a service for collecting, analyzing, and publishing objective information. The information furnished through research is a form of market intelligence which the private enterprise system utilizes in making decisions in the marketing of farm products. The application of this information within the framework of the competitive system contributes toward improved efficiency in the food and fiber industries which, in turn, helps sustain a viable economy and a high standard of living. Likewise, research findings provide a basis for developing guidelines in public policy as well as concepts for needed new legislation.

Market intelligence sought through research is furnished in areas such as: (1) measurement and evaluation of changes in the structure of the market and the impact of changes on producers, processors and distributors; (2) performance of the market in terms of efficiency and equity are continually being assessed; (3) farm-retail price spreads are maintained on a continuing basis for the major commodities and reported specifically to a congressional committee as well as to the general public; (4) studies in interregional competition, pricing, and transportation form a part of the research program; (5) evaluation of public programs as they relate to the farm economy and public welfare are analyzed; (6) means of improving farmers' bargaining power in the marketplace are continually under study; and (7) work in utilization economics as it pertains to new products and processes form a part of the research effort.

Ideally, market researchers would like to be able to analyze the huge and complex modern marketing system, as an entity at one time, but even with all our advanced technology and modern research methods, a simultaneous analysis is not possible. There is need to select components of the system for analysis. Those selected pertain to: (1) individual firms, (2) competition between firms, (3) bargaining power of farmers, (4) consumer aspects, and (5) location and growth. The nature of the research program in each of these components is as follows:

A. Efficiency of Resource Allocation in Marketing

This area refers to the efficient use of resources within firms, i.e., outputs of marketing services for given inputs. The inward looking or "in-firm" effect of competition is a continuous effort to become more efficient. Research on the efficiency of performing the marketing functions evaluates the impacts of reduced costs and subsequent adjustments on farmers, marketing agencies and consumers. It relates to the adoption of new technology and innovations by marketing firms and its effect on costs of distributing farm products. In some cases, evaluation of alternative methods of performing the marketing functions is made possible through generating input-output coefficients which demonstrate least-cost methods of performing an individual function. Relationships are shown between costs and alternative methods (innovation and technology) or between costs and volume (economies of scale). Research which describes the flow of products through the various marketing channels is designed to provide sufficient background knowledge to evaluate efficiencies in performing the various marketing functions.

B. The Competitive Situation of Marketing Firms

Competition is generally considered as a regulator of the economy. Although there are numerous forms of competition, price is the common denominator for expressing it in the marketplace. Farmers and businessmen responding to prices choose what products and services to offer and then bid for the resources needed. Performance improves as firms try new ideas and use knowledge gained from research and experience. Research in this area is concerned with the organizational characteristics and practices of marketing firms which affect competition among firms and their relative bargaining position as both buyers and sellers. Studies relate to the measurement and evaluation of concentration, mergers and the various dimensions of integration and diversification of firms. These factors assist in evaluating the marketing position or power of the intermediary marketing agencies. Information on profit ratios and descriptive statistics relating to the farm-retail price spreads and the Marketing Bill serve as benchmark indicators of market position and power.

C. Bargaining and Income Position of Farmers in Marketing

Market power is the ability to influence prices or other terms of trade in a way favorable to a business firm or group. It has long been assumed that, because of the purely competitive structure of the production process in agriculture, farmers are at a disadvantage in the marketing process. Consequently, considerable public enabling legislation has been enacted to strengthen the bargaining and income position of farmers. Examples are the establishment of publicly financed market news, crop reporting and estimating, and legislation to enable farmers to band together in their

buying and selling activities. Farmers also engage in self-sponsored programs such as advertising to differentiate their products in the marketplace. Continuing research is designed to evaluate the effectiveness of these programs and to seek alternative ways in which farmers can organize to strengthen their market and income position.

D. The Role of the Consumer in Marketing

The level of demand for a commodity is commonly thought to be determined by consumers' scales of preference, consumers' incomes or purchasing power, prices of other commodities, expectations about future prices, and number of buyers. This raises the question of how well the changing marketing system serves the consumer. The fact that consumers are continually changing creates an ever-present problem in this area. Research in marketing economics concerns itself with the interests of the consumer as well as those of the farmer and marketing agencies. Research in this area is designed to facilitate the communication of consumers' wants and desires back through the marketing system to the production process. Research is designed to evaluate the nature of demands so that resources can be more efficiently allocated in the production process.

E. Location and Growth Economics

The place where certain activities occur and the extent of those activities are influenced by the kinds of products produced and processed, the technology employed, the channels of trade through which the products move, the size and number of firms, and the trading relationship among firms. Changes in the cost of transportation have probably influenced competition in local markets and between regions as much as changes in total number and size of firms in the nation. This area of work is interrelated with the four areas previously discussed. Studies relating to regional and interregional competition rely on considerations of both the supply and demand of farm products along with considerations of the physical efficiency of performing the various marketing functions. These considerations form a basis for evaluations of the relative location and competitive advantage of individual regions or industries. The relative competitive position of producers and marketing firms in each industry is changing constantly. Changes in transportation rates, costs of inputs, available technology and the organization of industries in various areas have continuous impacts upon the position of each area. Constant evaluation of the changing competitive position of major areas and of prospective further changes is needed by potential investors in considering facilities for processing and storing the production in new and developing regions.

Research studies are often conducted in cooperation with other USDA agencies, other Federal Departments, and State Agricultural Experiment Stations. Cooperative work is undertaken with processors and distributors of agricultural products, transportation agencies, and agriculturally-oriented

groups. Financial contributions to the division's research efforts are sometimes made by industry groups which provide a strengthening of the research effort.

The research program and related program activities are conducted from headquarters in Washington, D. C. A limited number of field stations are located throughout the United States, a major part of them being at land-grant institutions. Field station personnel perform a special service by keeping the division alerted and informed on emerging problems in marketing as well as conducting joint research projects with station personnel. Also, economists are located at each of the four USDA Utilization Research and Development Laboratories. The total effort devoted to marketing research during the reporting year amounted to approximately 118 scientist man-years. The effort devoted to animal and animal products amounted to 8.0 for dairying; 12.3 for livestock and meat; and 14.5 for poultry and eggs.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Efficiency of Resource Allocation in Marketing

Livestock

Packers' delivery costs for mixed loads of meat averaged 83.7 to 87.3 cents per hundredweight for average hauls of 160 and 220 miles with average loads of 8,600 and 10,600 pounds under winter and summer conditions. Detailed analysis showed (1) varying road and traffic conditions could account for up to 30 percent variation in driver man-hours for identical loads and distances, (2) truck and driver costs each accounted for about 40 percent to 60 percent of total delivery cost, (3) delivery costs increased with length of haul, number of delivery stops, and decreased with larger total loads and average volume per delivery.

A linear programming model of the optimal product mix in hog-slaughtering operations was developed and tested by one meatpacking firm. A forecasting sub-system was used by the firm's management in planning procurement, product flow and marketing strategy. An allocation sub-system determined the optimal procurement and product flow. A comparative performance report compared actual firm performance with the optimum. This model was then generalized for use by any firm.

Poultry and Eggs

In a study of least-cost systems of assembling, processing and distributing eggs, it was found that when realistic values are assigned to farm labor and equipment, the choice between processing eggs on the farm and in a central

plant depends on the size of farm and plant. Generally, processing in a plant is less expensive due to economies of scale and small farm size. Processing in central plants generally is accompanied by increased pickup and delivery cost per dozen. When typical producing unit sizes for Pennsylvania are considered, the optimum solution excludes all farm processing and includes processing plants located in the areas with most production.

Costs of assembling live turkeys for processing are mainly affected by size of bird, crew size, load size, weather conditions, method of loading, flock size, and density of the production area. Under standardized conditions, density is a much more important consideration than flock size. For a plant requiring 42.4 million pounds of live, heavy-type turkeys per year, and with production density at 20,000 pounds per square mile, total costs of assembling were .26 cents per pound with 5,000 bird flocks and .23 cents per pound with 50,000 bird flocks. For 20,000 bird flocks, costs ranged from .38 cents per pound at a density of 5,000 pounds per square mile to .18 cents per pound at 80,000 pounds per square mile.

B. Competitive Situation of Input and Output Marketing Firms

Livestock

During 1961-64, the number of federally-inspected meat processing firms increased from 1155 to 1322, as 103 firms exited from and 270 firms entered the industry. Entry of meat processing firms was most rapid in the densely populated regions of the United States. While firm numbers grew, average volume also increased, by nearly 1 million pounds. But specialization in meat processing remained about the same--64 percent of federally-inspected processing plants did not slaughter livestock. As size and numbers grew, there was a slight decline in concentration of federally-inspected meat processing in large firms. The four largest firms did 35 percent of federally-inspected processing in 1961 and 31 percent in 1964. This reflects the changing size structure of the industry. Firms which entered had a larger average size, but smaller variation in size, than firms which exited. Persisting firms tended to grow in size and became more equal in size during the period, chiefly because small firms tended to grow faster than large firms.

Patterns of change in size structure of the federally-inspected slaughter industry during 1950-62, documented in previous reports, parallel those of the processing industry in 1961-64. Concentration declined, average size increased, and variation in size decreased. On the average, small federally-inspected slaughter firms grew 4 times faster than large firms. However, growth characteristics vary markedly among firms slaughtering different livestock species. It is hypothesized that observed growth patterns are due chiefly to: (a) the pattern of scale economies in livestock slaughter, (b) different investment alternatives between large and small firms, and (c) different patterns of plant location between large and small firms.

Poultry and Eggs

Producer groups and others have become increasingly concerned about the accuracy and usefulness of the present base price quotation system and possible alternatives for eggs. It is difficult to predict short-run variations in egg prices with formal models. In part, this stems from a lack of short-run market information series on movements, holdings, supply, indicated supply trends, and demand. Available information is from many reports and is not consolidated. However, many price changes appear due to psychological elements and expectations that prices "ought" to rise or fall at certain times as they have historically, rather than actual changes in supply and demand. With much of the country tied to the New York base price quotation and to reflections of trading on the New York Mercantile Exchange, price fluctuations may be too frequent and "the market" seems to frequently over-react. The New York base price quotation principally reflects the local wholesale supply and demand situation as expressed through trading on the Mercantile Exchange while frequently the New York situation is not indicative of the supply-demand relationship of the remainder of the country. Also, the quality of eggs traded on the Mercantile Exchange is inferior to consumer grades of cartoned eggs.

For 1961-66, the producers of large Grade A eggs received the highest average share of the retail price, 58 percent compared to 57 percent for turkey producers and for poultry products--50 percent for broilers. As with retail price, farm-equivalent value of poultry products varied from year to year. Farm-to-retail price spreads in the 12 cities varied from city to city but averaged 23 cents per dozen for Grade A large eggs, 20 cents a pound for Grade A frying chickens, and 21 cents a pound for Grade A medium size turkeys from 1961 to 1966.

Dairy

Milk processors, especially small and medium-sized independents, have been much affected by changes in their competitive environment. They are acutely aware of the effect of the greatly increased market power of the food chains upon their competitive position. Many processors, particularly, but not exclusively small volume operators, are leaving the industry. The extent of the adjustments made by processors who are continuing in business varies widely. Most independents whose businesses appear to be in good condition have modified their operations, attempting to adapt them to the changing competitive situation. Most small operators who continue in business distribute milk principally on home-delivery routes or else through specialized dairy stores.

The farm-retail spreads for butter account for the lowest percentage of the retail prices of dairy products, and those for ice cream the highest; the other three products are closely grouped in the middle range. A comparison of the average farm-retail price spreads for the entire group of dairy products with farm prices of milk since World War II shows that more efficiency has been gained in the production of milk than in its marketing. Dairy farmers produce more milk at a lower price as a result of mechanization, larger herds, and increas

output per cow. The average farm-retail spread--which is the price for performing the marketing functions of processing, transportation, storage, and distribution--has widened. The wider spreads indicate that the more efficient methods which have been adopted have not been sufficient to offset higher costs.

A spatial equilibrium model is a useful device for analyzing the geographic alignment of Class I prices in all Federal order markets. Order prices in 1965 were lower than the equilibrium prices in the upper midwest and higher in the northeastern markets, Florida, the south central area, and in Western Iowa, Nebraska, and South Dakota, for one model.

C. Bargaining and Income Position of Farmers in Marketing

Poultry and Eggs

Grower returns for poultry and eggs under various types of production contracts are affected by input prices, production efficiency, and market prices for the individual commodities. Through various ranges of commodity prices, input prices and production efficiency, the advantages of a contract for a grower may change relative to other contracts. Contract provisions often are not clearly defined with some problems of interpretation arising.

Wool

A study is underway which evaluates the effectiveness of the domestic marketing system for shorn grease wool. Included in these analyses are wool growers' evaluations of local pools, warehousing, and processing. Findings indicate that wool growers generally are satisfied with the wool marketing agencies with which they deal. Many local wool pools have not taken full advantage of their unique position in the wool marketing system and are in need of improvement. In addition, some wool warehousing and procurement operations have not kept pace by adopting some new methods and practices. Most wool processors recognize the poor preparation and inefficient marketing practices of many local pools in the Southeast and do not purchase wool from them. This research was requested by and is being conducted in cooperation with the National Wool Marketing Corporation and the American Farm Bureau Federation.

Promotion Evaluation

Analyses of published reports issued by the Department, State Experiment Stations, and other agencies on the subject of advertising and promotion are being made and interpreted from the viewpoint of economic implication to agriculture and development of general principles that will have widespread application. These analyses are nearing completion. Tentative conclusions indicate a number of problems of a technical nature in planning and conducting promotional activities which affect the economic consequences of such activi-

ties. Tentative principles include: (1) The chief role of advertising and promotion is communicating product information and attracting the attention of consumers. Advertising and promotion are competitive devices substituting for personal selling which must be carefully coordinated with other activities in the marketing system, (2) promotional activities should be directed toward carefully selected market targets for maximum effectiveness, and (3) sales response to promotional activities for agricultural products is related to the elasticity of demand of the product being promoted.

D. Role of Consumers in Marketing

Livestock

The unhairing of uncured hides at packing plants eliminates curing, reduces transportation costs and results in better quality leather. Total savings on raw material costs to tanners are about 15 percent. The segmenting of bellies, heads and shoulders from hides prior to tanning creates product differentiation, improves quality and results in greater net returns to all segments of the hide and leather industry. Heads, trimmings and unwanted or low value portions of a hide yield a greater net return to the packer when they are converted into a high protein feed than when used for leather.

Poultry and Eggs

Further processing offers the prospect of expanding total usage of poultry meat. Expansion of production should be gradual, in line with needs, and not regarded as likely to easily replace more traditional product forms. The degree of concentration is already high in the further-processed products industry except on specialty items. Substantial economies of scale exist in **producing** further-processed products. This will eventually result in a downward trend in plant numbers. Marketing costs are important in relation to production costs and the competitive environment relatively imperfect. Many plants will be located close to markets designed to serve the institutional trade or exploit local preferences. On the other hand, large volume mass-market items can be more efficiently produced close to major poultry producing areas. Further-processed egg products can be a feasible enterprise in the South provided certain conditions as to location, volume, size of plant, and other requirements are met. A crucial factor will be the nature and degree of product mix. Small seasonal operations producing only whole eggs will be unprofitable under most conditions.

Dairy

Significant percentages of raw food costs in selected samples of 9 types of institutions are represented by fluid and dry milk products. Depending on the type of institution, the amount spent for fluid milk ranged between 6

and 22 percent of the year's total food expenditures. Purchases of evaporated, dry, and nonfat milk averaged 0.2 percent or less of the total food cost. Research involving 51 Midwestern and Eastern institutions indicate sterilized milk concentrate would have a favorable acceptance by institutional outlets. The major disadvantage of the product pertains to problems involved in reconstituting and serving milk concentrate as a beverage. Main advantages indicated were long shelf life, savings in refrigeration space, a more convenient and superior product over powdered milk, and the multiple use of sterilized milk concentrate.

Mohair

The Mohair Council of America has been given assistance in developing specifications for research which would be carried out under contract with a private firm. This research would be financed by the Council. It would evaluate the effect of changes in the structure and practices in marketing mohair on the demand for mohair. This study will assist the Mohair Council in identifying factors affecting the future demand for mohair and will evaluate the price competition existing in the mohair market from warehouses to fabricators. This research also will aid the Mohair Council in developing its promotion and advertising program.

Product Development and Utilization Research

Results of past research conducted in the areas of utilization, product development, market potentials, and market development suggest certain types of impacts of new technology on the interdependence between raw material suppliers and consumer product markets. Some of the observed or expected impacts of new technology are (1) changes in the utility of a farm commodity as a raw material used in making consumer products (turbo milling of wheat flour and beam houses and new hide trims for cattle hides); (2) substitution of a synthetic for a farm commodity (corfam for leather and cellulose and petrochemical sources fibers for cotton and wool in textiles); (3) changes in market value of farm commodities because of change in utilization (use of low-grade potatoes, citrus and other products for which consumer demand has increased for processed forms); and (4) shifts in location of production, because of advantages or savings stemming from processing or preserving innovations, and developments in transportation.

During the past year market growth rates and the market shares attributable to farm commodities and to synthetics in soaps and detergents, textile fibers, glycerine, protein feed, sweeteners, shoes, perfumes and flavors and ethyl alcohol were analyzed. In each, agricultural commodities' share shows a lesser growth rate than its synthetic competitor and less than the market growth rate.

A product test of foam spray-dried milk was conducted in 8 nonprofit institutional food services in the Washington, D.C. metropolitan area. The foam spray-dried whole milk was rated acceptable for beverage use by the food managers. The study also revealed that current milk use and handling practices, health regulations, and cost can be expected to have an influence on the market possibilities for the product. Judging from the preliminary study, significant progress has been made toward the development of a beverage quality dry whole milk.

In the past year, an important accomplishment has been the completion of a long-range research project in the feed area. Purpose of this research was to evaluate the economics of the new feed ingredients developed by utilization researchers. The evaluation was based on an adaptation of a least-cost linear programming matrix which allowed a determination of the quantity of new feed materials that will meet the formula requirements for different animal rations at least cost, and the price range in which these feed materials must fall to make them competitive with other feeds supplying the same nutrients. Initial attention was given to alfalfa meals of differing protein contents. Eventually, consideration will be given to safflower, castorbean meal, and to mill feeds. Of importance to program guidance in this area is the development of this type of matrix for analysis, coupled with the fact that computers are now available at most of the laboratories and staff members will be able to make computer runs for other new feed ingredients to determine their intrinsic values in different animal rations.

E. Location and Growth Economics

Livestock

A spatial model developed in the North Central Regional Marketing work was used to simulate interregional competition in the beef and pork sectors under several shifts in production, consumption, transportation rates and slaughter capacity.

Simulated alternatives in the beef sector: A 10- to 20-percent reduction in transportation rates for long distance hauls reduces total transportation cost \$18.5 million without affecting shipment patterns. Increasing slaughter capacity to the point where all cattle are slaughtered locally would reduce the national transportation bill for livestock and meat by \$35 million. Slaughter cattle production could be increased at minimum interregional transportation cost for cattle and beef in the Southeastern United States. Pork sector: A shift from slaughter hog to feeder pig production in the states surrounding the Corn Belt would reduce the cost of pork shipments more than the live animal transport costs would be increased.

Poultry and Eggs

The regional distribution of egg production is affected by (1) technical efficiency; (2) structural characteristics; and (3) institutional arrangements. Technical knowledge is equally available to all areas, but not uniformly applied. As a case in point, the structure of the Midwestern egg industry is such that it is less efficient in performing input-supplying and marketing functions and has lost ground in comparison to other areas. More recently, new types of organizations have also emerged in other regions to influence prices and/or promote more orderly marketing. Unless the Midwest finds an effective answer through organizations of its own, it may find itself further disadvantaged. Modernization of the Midwestern egg industry would involve (1) fewer and larger producing, input-supplying, and marketing units; (2) greater coordination of these functions; and (3) improved egg quality. Modernization would require substantial capital investment. Reduced costs for major inputs such as chicks and feed, and lower marketing costs might enhance producer returns and attract the necessary capital. Egg quality in the Midwest averages lower than in the Northeast, South, and on the West Coast.

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COOPERATIVE MARKETING
Specialized Cooperative Research Program, FCS

Problem: Farmers continue to increase their use of marketing cooperatives.

Marketing cooperatives face major changes in handling, processing, transportation, and distribution technology as well as in market organization and practices. Farmers also have changed and cooperatives need research findings to help members strengthen their bargaining power, increase marketing efficiency, and effectively meet the quality, quantity, and service needs of today's markets.

Farmers own and operate marketing cooperatives specifically to increase their income from the sale of crops and livestock. Gains are not automatic, however.

Cooperatives must plan and actually conduct the specific marketing programs and services that will yield best returns to their members. Marketing cooperatives must know what the consumer wants. They must be able to estimate the cost of serving the market in different ways. They must understand the possibility of major economies in a well-managed joint sales program, methods and potentials of bargaining, and impact of a changing market structure on operations.

Management must achieve minimum costs through appropriate organization, good use of existing plant and personnel, and correct selection and use of new equipment and methods.

USDA and Cooperative Program

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies cover organization, operation, and role of cooperatives in marketing. While the research helps improve cooperatives operations, the results often benefit other marketing firms.

The work is centered in Washington, D.C. The Service, however, has many studies done under contract or in cooperation with various State experiment stations, extension services, land-grant colleges, universities, cooperatives and private research organizations.

Federal scientific man-years devoted to research in this area totaled 11.6. Of this number, 1.7 was devoted to improving sales, distribution, and pricing practices; 3.5 to potentials in cooperative marketing; 2.6 to improving operating and handling methods; and 3.8 to improving the organizations, financing, and management of marketing cooperatives. All research was in the field of economics, of which 4.0 SMY's were devoted to livestock.

Program of State Experiment Stations

The research effort of the State experiment stations in this area totaled 2.8 scientist man-years.

Progress -- USDA and Cooperative Programs

A. Improving cooperative sales, distribution, and pricing practices

Dairy.--Analysis of the operations of dairy cooperatives shows that about 75 percent of their milk is of Grade A quality -- well above the national average. Producers of Grade A milk are assigning greater marketing responsibilities to their cooperatives. In disposing of surplus Grade A milk (that not needed for fluid use), producers face the same marketing problems as producers of manufacturing grade milk.

In many large fluid milk markets, farmers have strengthened their marketing position by consolidating their cooperative marketing operations. Also, they have strengthened their bargaining position through federated marketing programs, some of them regional in scope.

Need continues for pooling systems to increase the efficiency of cooperative marketing operations and to increase their market power.

B. Potentials in cooperative marketing

Dairy.--During the 1957-64 period, the number of dairy marketing cooperatives decreased by one-fifth, yet their total volume of milk marketed increased by one-third, a recent study showed. Volume of the average cooperative increased by three-fifths.

Over two-thirds of all dairy cooperatives are located in the North Central region. Many operate small creameries and cheese plants and do not have adequate volume to justify the installation of modern, automated equipment required for low unit cost operations.

Further analysis is being made of potential benefits to dairy farmers from increased coordination in their marketing activities.

Livestock.--The agency completed a study of the feasibility of establishing livestock slaughtering-meat processing and marketing cooperatives in Vermont. Findings indicate that Vermont farmers need a new meat plant to provide a dependable market for their cull dairy cows and veal calves. Available livestock supplies, market outlets for meat products, and sources of financing make a meat plant feasible if producers will support it with both their livestock and their capital. A plant killing 500 cattle and 1,000 calves a week could add \$280,000 a year to producers' incomes. The Vermont Agri-Business Council is now working to implement the study's recommendations.

Another study was appraising the potential for cooperative cattle feedlots in the Southeastern States. Preliminary investigation indicates a need to feed 2 million more cattle in the area to meet rising consumer demand for fed beef. Cattle feeding is growing in the Southeast and there is a need for cooperative feedlots to help farmers share in this expanding industry.

Poultry.--The Service started an appraisal of the status, role, capabilities, and future of farmers' turkey marketing cooperatives.

Work continues to determine whether it would be feasible to establish cooperative marketing facilities in the Northeast to market fowl.

C. Improving operating and handling methods

Dairy.--Studies on combining operations of dairy cooperatives show that greatest benefits exist where cooperatives have unused plant capacity. Where this capacity is scattered over a wide geographic area, selection of the best alternative becomes more difficult.

The Service has a study underway to develop a standard departmentalized cost accounting system to provide information needed to control cost and help select the best operating alternatives.

Livestock.--The Service completed a study of the feasibility of pooling veal calves at a group of eight cooperative auctions. The study found that pooling would be feasible at six of the eight auctions and would increase producers' net returns from calves by \$150,000 to \$200,000 a year. The study also outlined procedures for organizing and operating an efficient and successful pool.

Guidelines were developed for organizing and operating wool marketing pools.

Work continued on a study to improve operations and services of two large livestock cooperatives in the Midwest. These cooperatives have expanded their off-the-terminal market operations and increased the volume of livestock handled and services rendered to members. Ways to integrate and coordinate services of the two organizations are being evaluated.

D. Improving the organization, financing, and management of marketing cooperatives

Dairy.--Three studies on the feasibility of unifying operations of cooperatives show that changes in milk supplies have left many dairy cooperatives with unneeded plant capacity, and facilities both mislocated and antiquated.

These studies further indicated a major problem in unifying cooperative operations is the lack of farmer understanding of the alternative legal steps and their implications.

Publications -- USDA and Cooperative ProgramsPotentials in Cooperative Marketing

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Improving Organization, Financing, and Management

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ECONOMIC AND STATISTICAL ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem. Frequent accurate appraisals of the economic prospects for important agricultural commodities are necessary if farmers are to plan and carry out their production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for making sound production and marketing decisions. Such information is provided through a flow of current outlook information, the development of longer range projections of the economic prospects for the principal agricultural commodities, and analyses of the economic implications of existing and proposed programs affecting major farm commodities.

Producers, processors, distributors, and consumers need information based on accurate quantitative knowledge of the interrelationships among prices, production and consumption of farm products, and other factors. Similarly, Congress and the administrators of farm programs need such economic information to evaluate existing and alternative programs or policies in terms of their probable impact on production, consumption, and prices at both the farm and retail levels. The research program in this area provides the information for strengthening outlook and situation work, and for appraising alternative policies for agricultural products.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-range program of economic and statistical analysis directed in two major areas: (1) commodity situation and outlook analysis; and (2) supply, demand, and price of agricultural commodities.

The program pertaining to situation and outlook includes a continuous appraisal of the current and prospective economic situation of the major crop and livestock items. These appraisals, together with developments of interest to the industry and results of special studies, are published four to six times a year in the various commodity situation reports. Brief resumes are carried in the quarterly Demand and Price Situation and, when appropriate, in monthly issues of the Farm Index and the Agricultural Outlook Digest. Pertinent information is also presented at the Annual Outlook Conference, at regional and state conferences, and at meetings with industry groups. Statistical handbooks are published periodically for livestock and a number of the field crops. The current Federal effort involves 19.5 SMY's, of which 4.5 are devoted to livestock and meat; 2.0, dairy; and 1.0 to poultry and eggs.

The program of basic research into the factors affecting prices, supply, and consumption of principal agricultural commodities is concerned with four broad areas: (1) measurement of consumer response to price, income, and other factors; (2) measurement of producer response to price and other factors; (3) measurement of the effect of supply and demand factors on prices to farmers and to consumers; and (4) improvement of statistical techniques for measuring economic relationships in agriculture. The USDA program of research in this area involves 9.5 scientist man-years and is located in Washington, D. C., of which 2.0 SMY's are devoted to livestock and meats and 0.5 SMY to dairy.

PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the States depend heavily on the USDA for across-the-board commodity situation and outlook research. However, the State Extension staff members supplement and adapt such research information to meet the commodity situation of their States. Many of the States carry on supply, demand, and price analyses for the products of their State. Much of the research is commodity-oriented though some projects are of a highly mathematical and theoretical nature aimed at improving price analyses methodology. While not designed as outlook research, much of the research conducted by the experiment stations contributes to improved understanding of price-making forces, which in turn improves market situation analysis and price forecasting.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Commodity Situation and Outlook

A. Livestock and Meat

A reappraisal of the cattle cycle was made after revisions in the January 1 inventory numbers were released in February 1967. Discussions of the changes in the outlook for cattle because of the 2% upward revision in the number of cattle on farms were included in the March Livestock and Meat Situation. Further stress was placed on the impact of the small downturn now underway in the inventory in the August issue. The feeder cattle supply has stabilized somewhat and it is now unlikely that the level of fed cattle marketings will increase very rapidly in the next year or so.

A major section of the May issue of the Situation was focused on foreign trade in livestock and livestock products. Beef and veal ranked first among these products in value of imports in 1966, followed by wool and pork. The export value of the animal fats -- tallow and greases, and lard -- was the largest, followed by hides and skins and variety meats.

B. Dairy

In response to industry interest in dairy imports and to the need for information relating to import regulation, special studies were made of the world dairy situation, dairy policies in other countries, and U. S. imports. A monthly summary of dairy imports has been developed for dissemination by the Dairy and Poultry Market News Service. Declining demand for dairy products brought about the development of quarterly estimates of dairy product consumption. In addition, a special study was made of blended food products containing chiefly corn, soybeans, and nonfat dry milk for use in foreign food programs. Evaluation was started on governmental participation in fluid milk pricing and of state fair trade practice regulations.

C. Poultry and Eggs

An analysis was made of the effect of increasing production of poultry, eggs, and competing red meats on prices of poultry and eggs. In the February 1967 issue of the Poultry and Egg Situation special attention was given to the broiler situation in the European Economic Community. The April issue carried a report on the changes made by the Statistical Reporting Service to improve the chicken inventory data. The effect of revisions in data based on the 1964 Census of Agriculture was discussed.

D. Wool and Mohair

Increasing emphasis has been placed on appraising the world supply and demand situation for wool in conjunction with the domestic wool economy. A meeting was held with other major producing and consuming countries to study methods of improving data on the world wool industry and wool's competitive position relative to other fibers. Appraisals were made of the U. S. wool tariff in view of the international negotiations on trade and tariffs. Attention was given to the effect of a possible tariff reduction and its relationship to the U. S. Wool Act program, income to domestic producers, and consumption of wool. Duty rates would not change for wools imported in large volume but rates of low-quality wools would be reduced 50% in five equal annual installments beginning January 1, 1968. A new series of monthly deliveries of wool, cotton, and man-made fibers to the U. S. military forces was developed for the Wool Situation. This series was first published in October 1966 including data beginning with 1961.

II. Supply, Demand and Price

A. Livestock and Meat

An analysis of beef production by class and grade was published. It showed the increasing importance of fed beef in total beef production. Fed cattle marketings which accounted for about 36% of all cattle marketings in 1946-48 rose to 66% of the total in 1964-66. High-quality meats, Prime, Choice, and Good, over the same period rose from an average of 52% of total beef production to about 69 percent.

Performance of the Livestock-Feed Grain Economy was the title of an article published in the Journal of Farm Economics. There has been a trend in the past two decades toward greater stability in feed grain production and prices as well as in livestock production. However, similar trends cannot be detected with respect to livestock prices, particularly for hogs.

An analysis of regional shifts in livestock was published. The number of farms and ranches raising livestock in the past decade declined substantially while the number of livestock, except sheep, increased. Progress continued on improving the quarterly supply model for hogs developed in 1962 for determining the number of pigs saved and slaughtered and the price of hogs. Additional factors are being considered to adapt the model to recent structural changes in the industry.

B. Poultry and Eggs

A report, Competitive Position of the Midwestern Egg Industry, co-authored by the division's poultry analyst was published in February 1967. Trends in egg production and marketing in the Midwest were compared with those in other regions. The market structure and practices in the industry and changes needed to make the region more competitive were analyzed. The low density of production, and smaller feed-mill and chick-hatchery operations, result in higher costs than in areas of intensified commercial production. Many areas have more deliveries to retail stores and warehouses, bypassing wholesale receivers and distributors in terminal markets. The Midwest continues to market eggs through the more traditional, longer, and costlier marketing channels.

C. Dairy

Basic research was begun to provide a comprehensive analysis of the factors affecting the supply, demand and price for milk and dairy products. Preliminary results indicate that milk cow numbers are strongly influenced by the level of beef cattle prices while yield per cow is related to time or trend and is associated with technological change.

Manufacturing milk supplies appear to be more responsive to changes in returns from nondairy farm enterprises than are Grade A milk supplies. Responses, however, differ from one production region to another because of regional shifts in demand and in the competitive position of dairying relative to other farm and off-farm alternatives.

D. Wool

Projections to 1980 of wool production and consumption by regions of the world were prepared at the request of the President's National Advisory Commission on Food and Fiber. Increasing incomes and larger populations were factors associated with the anticipated increase in total world wool consumption. World production is expected to parallel the rise in consumption, but the rate of increase of both production and consumption will be slower than in recent years. Wool's share of total fiber consumption probably will decline as production and use of man-made fibers increase.

A study of trends in U. S. production of blend fabrics was printed in the October 1966 Wool Situation. Output of all blend fabrics -- wool, cotton, and man-made fiber -- during 1958-65 doubled while total fabric production rose 15% resulting in a continuing rise in blend's share of total. Of all blends containing wool in 1965 about 60% were principally wool and 40% were principally man-made fibers.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

I. Commodity Situation and Outlook

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Dairy

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II. Supply, Demand and Price

Livestock and Meat

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Poultry and Eggs

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Dairy

Miller, Robert R. March 1967. Changes in Dairy Farm Numbers. Dairy Situation, pp. 30-36.

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Miller, Robert R. September 1967. Seasonal Milk Price Variation. Dairy Situation, pp. 27-30.

CONSUMER ATTITUDES AND PREFERENCES
Special Surveys Branch, SRS

Problem. Domestic consumption of agricultural commodities depends on the behavior of some 190 million consumers. But, in our complex marketing economy, it has become almost impossible for consumers to discuss their preferences, opinions, satisfactions, and dissatisfactions with producers and marketers. Knowledge of consumer reactions to agricultural products is becoming increasingly important because we are in a period of rapid change: There is a growing challenge to farm products and farm income from a wide variety of competitive products of nonagricultural origin; there is a proliferation of mixtures, forms, processes, and other innovations affecting farm products; and that mistakes in developing, producing, and marketing farm products are costly not only to the farmer but to processors and handlers as well. An understanding of consumer reactions and the reasons behind them is essential to planning improvements in the production, marketing, and processing of agricultural products, developing educational programs, setting or revising grades or standards, evaluating new products developed by the Department's Utilization Laboratories, and identifying areas on which technical research should be focused to provide farm products in the forms and with the characteristics that will increase consumer acceptance and more closely satisfy consumer demand.

USDA PROGRAM

The Special Surveys Branch provides the consumer, in a scientific and unbiased manner, with an opportunity to say what he or she thinks about agricultural products by conducting applied research among representative samples of household, industrial, or institutional consumers and potential consumers. Such research may determine opinions, preferences, buying practices, knowledge and habits with respect to various agricultural commodities, the role of competitive products, and acceptance of new or improved agricultural products. The Branch also operates a sensory evaluation laboratory designed for small-group experiments in taste and visual preference and discrimination in which people's reactions to various products can be ascertained under controlled conditions. Such research applies to grades and standards problems and marketing problems as well as product development or product improvement efforts. These studies of the reactions of consumers which affect their purchase and use of farm products provide a line of communication from consumers back to those concerned with production and marketing, and are complementary to the marketing and economic research of the Economic Research Service and the Consumer and Marketing Service as well as to the utilization research of the Agricultural Research Service.

In addition, the Branch provides consultants and conducts special studies, upon request, for other agencies in the USDA or within the Federal Government, when survey methods can be usefully applied to the evaluation of programs, services, or regulatory procedures of interest to the requesting agencies. The research is carried out in cooperation with other USDA or

Federal agencies, state departments of agriculture, experiment stations, land-grant colleges, and agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are sometimes conducted by the Washington staff with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology or other social sciences, in Washington, D. C., which is headquarters for all the research whether it is conducted under contract or directly by the Branch. The Federal effort devoted to research in this area during the past year totaled seven scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

1. Pork and Beef. A study is being conducted among a nationwide sample of homemakers to ascertain their opinions, usage patterns, and purchasing practices for various meats and meat products, particularly pork and beef. The National Live Stock and Meat Board is cooperating with the Department on this study, and is providing a portion of the funds for the contract.

An exploratory study preceded the main survey in an effort to assure that pertinent factors would not be overlooked in developing the questionnaire. The questionnaire is oriented toward uncovering some of the reasons that underlie increased per capita consumption of beef on one hand and decreasing consumption of pork on the other. The interviewing on the main survey stated early in calendar 1967, and will cover all quarters of that year. A preliminary report, based on some of the more pertinent findings from the first quarter's interviews, should be available early in 1968.

2. Materials in shoe uppers. A survey is being conducted in the Philadelphia, Pa., area to ascertain the attitudes and opinions of consumers concerning leather, primarily in shoe uppers. The study, in which approximately 500 men and 500 women will be interviewed, will investigate consumers' opinions about the advantages and disadvantages of leather compared to competing synthetic products, and their impressions of the desirability of potential improvements in leather for shoes. If necessary, additional interviews will be conducted among users of "Corfam" shoes in an effort to obtain a large enough number for separate analysis. Attitudes toward leather in clothing are also being studied, again in comparison with competing synthetics currently on the market. Questionnaire development and pre-testing have been completed; interviewing is scheduled for the fall of 1967.

3. Dry Whole Milk. The final report is being prepared for publication on a study (financed in part by ARS) to evaluate consumer acceptance of a powdered dry whole milk developed by the Dairy Products Laboratory of the Eastern Utilization Research and Development Division, ARS.

The new powdered milk, which reconstitutes into fluid whole milk, was tested by a sample of over three hundred households in the Alexandria, Virginia area. Considering over-all needs and preferences, the dry whole milk was rated equal to or better than fresh whole milk by four out of ten of the participating homemakers. About three-fourths of the homemakers found advantages to the dry whole milk - the most frequently mentioned advantage was that it was lightweight and easy to store; the most frequently mentioned disadvantage was that the test milk takes time to prepare or mix.

Tentative plans were made for conducting a consumer survey phase as part of a market test in cooperation with ERS-MED to further investigate acceptance of vacuum foam dry whole milk.

A year long series of experiments conducted to test people's reactions to dry whole milk after varying periods of time in storage at different temperatures (40°, 68°, & 80°, Fahrenheit) has been completed. The milk that had been stored at the three temperatures was compared to a fresh whole milk which served as the control throughout the tests. Mean score ratings for the two samples which had been stored at 68° and 80°F, decreased steadily each month; they were dropped from the series after eight months of tests due to increased difficulty in reconstitution. However, the mean scores for the dry whole milk that had been stored at 40° remained fairly constant during this period, and even after a year in storage the mean score for the dry whole milk that had been stored at 40°F., was still above the neutral point (5.00) on the hedonic scale.

4. Fibers in Wearing Apparel. A nationwide study of women's attitudes toward cotton and other fibers used in wearing apparel has been completed, and the final report is being readied for the printers. Some highlights of the findings follow: While there are important variations in the purchase requirements that apply to the different clothing items, women (as might be expected) generally consider color, style and fit in any clothing purchased. For summer dresses and between-seasons dresses, comfort and weight along with ease of care are the next most important considerations. However, there is less focus on ease of care and more concern with multiseasonal use and whether the garment is appropriate for many occasions in selecting between-seasons dresses.

In purchasing warm-weather knit dresses, warm-weather suits, and skirts, interest centers on shape retention and warm weather comfort. For blouses and slips, care and laundering are the next most important factors.

In response to a question on how long they expected their garments to last, the majority of the women interviewed said they wanted to get at least two or three seasons use out of them. When asked how they cared for the specific garments included in the study, just as many women said they hand

washed as well as machine washed summer dresses, skirts, blouses, and slips. Between-seasons dresses, knit dresses and warm-weather suits are dry cleaned by the majority of the women interviewed.

According to these women's responses, cotton was still the dominant fiber with respect to ownership and preference among the items studied, with the exception of slips where nylon is the leader.

Cotton implies a number of important benefits. It is cited for its good appearance and fit characteristics. It is cool and lightweight and also offers easy care features. For most end uses, respondents mentioned rayon and nylon as the least liked fiber. They were both faulted for fraying and pulling at the seams, for being difficult to iron, and clinging to the body. Many women said that nylon was warm. Rayon, on the other hand, was thought to be cheap looking, wrinkled easily, and lost its shape.

Respondents were questioned on three special fabrics: stretch fabrics, machine washable woolens, and wash and wear. About one out of four women said they owned a summer garment made of a stretch fabric. The main attribute given for these garments is their comfortable fit. Cotton, because it is cool and washable, is the fiber most women preferred in a stretch garment for summer use.

About half of the respondents said they were aware of machine-washable wool; however, only one-tenth owned a garment made of this fabric. Those who said they owned garments that were made of machine-washable wool said they were easy and economical to care for, but did not keep their shape.

About three out of four women owned wash and wear clothes. Cotton-and-synthetic blends are preferred for wash and wear largely because of their reduced ironing needs, wrinkle-resistance, and quick-drying qualities.

A contract has recently been signed with the private research firm which conducted the women's clothing study cited above to conduct supplemental analyses on these data. This additional research will expand insights into the issues that underlie women's fiber preferences in specific clothing items through a detailed examination of the interrelationships among the reasons given for fiber preferences as well as general attitudes toward fibers. It will be of value in interpreting data already collected as well as in planning future studies.

PUBLICATION

Knott, Edward M. 1966. Homemakers' Opinions and Preferences for Broiler-Fryers and Turkeys. MRR-760. (S&R 3-8)

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